SUMMARY REPORT

OF THE

MINES BRANCH

OF THE

DEPARTMENT OF MINES

FOR THE CALENDAR YEAR ENDING DECEMBER 31

1918

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1920

To His Excellency The Duke of Devonshire, K.G., P.C., G.C.M.G., G.C.V.O., etc., etc., Governor General and Commander in Chief of the Dominion of Canada.

MAY IT PLEASE YOUR EXCELLENCY,—

The undersigned has the honour to lay before Your Excellency, in compliance with 6-7 Edward VII, chapter 29, section 18, Summary Report of the work of the Mines Branch of the Department of Mines during the calendar year ending December 31, 1918.

MARTIN BURRELL,
Minister of Mines.

HON. MARTIN BURRELL,
Minister of Mines,
Ottawa.

SIR,—I have the honour to submit, herewith, the Director's Summary Report of the work of the Mines Branch of the Department of Mines during the calendar year ending December 31, 1918.

I am, Sir, your obedient servant,

R. G. McCONNELL,
Deputy Minister.

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SUMMARY REPORT

OF THE

MINES BRANCH OF THE DEPARTMENT OF MINES, FOR THE CALENDAR YEAR ENDING DECEMBER 31, 1918.

INTRODUCTORY.

The marked advance made in the mining industry of the Dominion during the season of 1917, was continued in 1918, resulting in a 10 per cent increase in mineral production. The urgency of the demand for metallic and non-metallic war materials stimulated this increased production; in the attainment of which the technical facilities offered by the Mines Branch were utilized to the fullest extent, thus materially assisting in the supply of minerals, etc., required for munitions, as well as aiding in the general development of the mining industry.

The work accomplished by the Mines Branch in connexion with the abovementioned industrial operations covered a wide scope, necessitating not only extensive field and laboratory investigations by technical officers of the Branch, but entailing a very considerable increase in office duties as well.

Compliance with the extraordinary demands due to war-time conditions, and the urgent needs of the rising industries of the country, involved the examination of certain metallic and non-metallic mineral occurrences, including deposits of pyrites and limestones, and certain sand and clay areas; also practical work in the various physical, chemical, and testing laboratories, on samples of ores, fuels, oil, gases, etc. Moreover, many specimens were submitted for identification, accompanied by requests for a statement as to their economic importance; while applications were received for technical advice with regard to the intrinsic value and commercial prospects of certain mineral deposits; or with reference to problems and difficulties encountered in the manipulation and manufacture of certain metals and their associated products. And this technical work was supplemented by the collection of statistics relating to the mineral production of Canada, these data being compiled, and issued for public distribution, as indicated in another section of this report.

In the subsequent pages, particulars will be found of the specific work done in connexion with the various Divisions of the Branch, by the different officers of the staff.

In addition to the statistical reports referred to, the following reports were published: Summary Report of the Mines Branch for the calendar year ending December 31, 1917; Building and Ornamental Stones of Canada: Vol. V.; Clay Resources of Southern Saskatchewan; Mineral Springs of Canada: Part II; also Analyses of Canadian Fuels: Parts I, II, III, IV, and V.

ORE DRESSING AND METALLURGICAL DIVISION.

As indicated in the previous summary report, the work of this Division was, first of all, confined during this year to the investigation of minerals much in demand on account of the war. The commercial milling of molybdenite ores, which constituted one of the principal activities of the division during the past season, was discontinued in July, as the demand for this product from the Imperial authorities had ceased, the remainder of the year being devoted to investigational and routine work on samples of several classes of ores submitted for concentration and milling tests.

In a subsequent section of this report is found a complete record of the several tests carried out.

FUELS AND FUEL TESTING.

The work during the season of 1918 by the Division of Fuels and Fuel Testing consisted in part in the preparation of a report setting forth the results of trials conducted at the Fuel Testing Station on the large number of commercial samples of coal obtained from Alberta. These tests were carried out to determine the value of these fuels for utilization in the gas producer and for steam-raising.

The chemical laboratories were fully occupied with the analyses of oils, gases, coals, peat and mine air, and in addition a large amount of research work was conducted concerning the treatment to which the lignites of Saskatchewan must be submitted in order to prepare them for briquetting.

An oil laboratory has been fitted up in which it will be possible to determine the value of fuels high in volatile matter, peat, and oil shales for the production of oils. In this laboratory two large gasometers and a semi-Deisel oil engine are installed and specially designed retorts will be erected in the immediate vicinity of the building for treating the various coals and oil shales. Preparations are now being made to undertake research work on the samples of oil shale which will be sent to our laboratories during this and other seasons from New Brunswick, Nova Scotia, and elsewhere. This research work will be of the same character as that which is now being conducted with the lignites. The investigation begun two years previously relative to the carbonization and briquetting of our western lignites is being continued.

The Chief of the Division of Fuels and Fuel Testing in addition to his regular duties as Chief of that Division has been appointed a member of the Dominion Power Board, and member and secretary of the Peat Committee. This latter committee is composed of two Federal members, and two members appointed by the province of Ontario.

Considerable work was also carried out by officers of this division in connexion with the determinations of the tensile and compressive strength and hardness of various steels for the Imperial Ministry of Munitions, Department of Militia and Defence, and other departments of the Government.

A special investigation concerning the properties of "Nicu" steel was also carried out by Messrs. Blizard and Hardy.

The laboratory for the calibration of pyrometers, which was installed a short time ago, has been placed in charge of Mr. E. S. Malloch, who already has made some twenty calibrations for this and other departments.

The demand for construction of apparatus and repairs to existing machinery and apparatus, and the erection of new machinery, etc., has been so great that a part of the shed which was formerly used for storing coal samples has been converted into a temporary annex to the machine shop. All machine work for the Mines Branch is performed in these shops.

METALLIFEROUS MINES DIVISION.

On account of the great demand for pyrites ore for use in making sulphuric acid for munition purposes, Dr. A. W. G. Wilson, Chief of the Division, spent several weeks investigating deposits in central Ontario. To his assistant engineer, Mr. A. H. A. Robinson, was assigned similar work, his whole field season being devoted to investigating the undeveloped pyrites resources of Eastern Canada, the scope of investigations including deposits in western Ontario, Quebec, and the Maritime Provinces. A report of the work done in this connexion will be found in another section of this summary.

Dr. Wilson also spent about seven weeks in the investigation of the processes in use in the United States for the recovery of potash from the waste gases of cement

plants. In addition, considerable of his time was taken up with War Trade Board activities, he having been appointed engineer in charge of pyrites and sulphur, and he also acted from time to time, as his services were required, as technical adviser to the Board.

INVESTIGATION OF LIMESTONE.

The investigation of limestone deposits, undertaken in the years 1916 and 1917, was continued by Mr. Howells Fréchette. The field work was confined principally to the province of Ontario, where localities not covered in the previous year's work were visited.

On account of the demand for dolomite, both for the production of lime and for its use in the wood pulp industry, a short time was spent by Mr. Fréchette examining certain areas favourably situated to centres of consumption.

INVESTIGATION OF GRAPHITE AND THE GRAPHITE INDUSTRY.

As intimated in the summary report of the previous year, there was undertaken an investigation of the graphite industry to stimulate the amount of the Canadian production. The work, which was commissioned to Mr. H. S. Spence, was proceeded with during the year 1918. The investigation embraced the revisiting of many mines and mills, and the exploration of several new properties, with a view to obtaining additional data needed to complete the report. In addition, it was necessary to visit a number of manufacturers of graphite products both in Canada and the United States. The data collected as a result of the above activities have been embodied in a report which is now being prepared for the press, and will, it is expected, be ready for distribution, early in 1919.

MICA.

During 1918, the Imperial Ministry of Munitions, being faced with a shortage of high grade mica suitable for magneto condenser plates, approached the Canadian Government with a view to ascertaining whether supplies of such mica were obtainable from Canada. In response to this inquiry, the Mines Branch transmitted, through the Imperial Munitions Board, samples of mica representative of the grades procurable from Canadian deposits. The sheets were tested for their di-electric strength by the Imperial authorities, and a report on the results obtained was sent to the Branch. The report submitted showed that certain of the samples—notably those from British Columbia—were eminently suited to the purpose indicated. An endeavour was made to interest owners of mica mines and claims with a view to obtaining supplies, but before any further action could be taken, a notification was received from the British Government that, owing to lack of tonnage, the project of securing mica supplies from Canada had been abandoned.

INVESTIGATIONS OF THE SANDS AND SANDSTONES OF CANADA.

Mr. L. H. Cole, the officer in charge of this investigation, which has been continued from the previous year, confined his activities to Eastern Canada, field work being carried on in the Ottawa valley, supplemented by special trips to visit occurrences in the vicinity of Fort William, the Kamouraska district northeast of Quebec city, and certain deposits in New Brunswick and Nova Scotia. The work so far done in connexion with this investigation is referred to in succeeding pages, under the caption "Preliminary Report on the Silica Deposits of Eastern Canada."

DISCOVERY OF ROCK SALT AT MALAGASH, NOVA SCOTIA.

In Cumberland county, N.S., there is being opened up a deposit of rock salt. The attention of the Department was first called to this deposit through results of analysis of a strongly saline water, obtained from a well being drilled in the vicinity. Parties interested were advised to proceed with the exploration, while Mr. L. H. Cole was commissioned to visit and examine the locality, with a view to furnishing an opinion as to the nature and extent of the deposit and as to its possible commercial value.

A short report on this subject, by Mr. Cole, is to be found in another section of this summary.

CHEMICAL LABORATORIES.

During the year a great variety of work has been assigned to the Chemical Laboratories, due to the activities of the several Divisions of the Mines Branch together with the work done for other departments of the Government service, such as the Department of Public Works, Fuel Controller's Office, Imperial Munitions Board, etc., and also requests for determinations of various natures from mining companies, prospectors, and others interested in the mining industry. The pressing and increasing demands for certain war minerals and their allied products have led to a special programme of investigation to stimulate such production, and in the course of the successful carrying out of this work the facilities offered by the laboratories, and the services of the limited staff of chemists have been fully utilized.

Reference to the specific work accomplished in the several laboratories of the Mines Branch is to be found in succeeding parts of this report.

DIVISION OF MINERAL RESOURCES AND STATISTICS.

The work of this Division has been directed to the collecting of that statistical data which forms the basis for the report on the annual mineral production of Canada. There is prepared early in the year by this Division from the information available at the time a preliminary report, which forecasts the probable mineral production for the season, which figures are revised in the annual report, when more complete returns are available.

The arrangement entered into in 1917 with the Census Office of the Department of Trade and Commerce, whereby that office shall accept as census records the statistics of mineral production collected by the Department of Mines has been continued during the year. In addition, special monthly or quarterly returns of the production of certain minerals and mineral products required for the successful prosecution of the war, were obtained, the data completed, and the information furnished to such offices as the Fuel Control, Canadian Munition Resources Commission, and the War Trade Board. In another part of the summary is to be found a complete report of the activities of the Division, for the year, submitted by the officer in charge.

CERAMIC DIVISION.

The functions of the Ceramic Division consist in the investigation, both in the field and the laboratory, of the clay and shale resources of the Dominion. During the year, examinations were made of certain clay areas in the Ottawa valley, and in eastern Ontario, and, in addition, a trip was made to Prince Edward Island to prospect deposits of tile clay. The laboratory work included the testing and reporting upon the numerous samples of clays and shales submitted for examination, and also special investigations have been conducted in connexion with certain refractories, while a great deal of assistance has been given the clay-products manufacturers, to enable them to solve the difficulties arising in the course of production.

ROAD MATERIALS DIVISION.

The scope of work undertaken by the Road Materials Division includes the locating, examining, mapping, and sampling of all deposits of available road materials occurring along proposed routes of main or other important highways throughout the Dominion. During the year, the Division's field work was conducted in Manitoba, Rocky Mountains Park, Alberta, and in British Columbia. These investigations were supplemented by extensive laboratory work, covering testing of samples obtained in the field, and experiments of an investigational nature, with a view to advancing the science of road building.

In the detailed account of the work of the Division appearing in another section there has been included the report by Mr. G. C. Parker of the Provincial Department of Public Highways, Toronto, with respect to the possibilities of using the bituminous sands of northern Alberta to surface rural roads.

TECHNICAL LIBRARY.

The library has grown to such an extent, during the year, that the additional shelving capacity, which was provided during 1917, has proved quite inadequate to meet the increased demands of 1918; in consequence frequent rearrangement of the volumes has been necessary to provide for this constant expansion.

A number of valuable new exchanges have been secured, and our efforts to re-establish exchanges and to secure publications which were discontinued through the period of the war, have met with encouraging results.

Additions to the library for the year: Total exchanges secured 1,837, which includes 483 bulletins, proceedings, transactions of scientific and technical societies—and 1,354 Government publications of scientific and technical value, comprising reports, memoirs, bulletins, maps, etc., 28 volumes have been added by direct gift, 157 by purchase, and 91 volumes bound, bringing the total number of volumes accessioned during the year, to 2,113.

EUGENE HAANEL,
Director.

INDIVIDUAL SUMMARY REPORTS.

METALLIFEROUS MINES DIVISION.

I.

Alfred W. G. Wilson, Ph.D., *Chief of the Division.*

During the year 1918 this Division employed only two field officers. The Chief of the Division, Dr. A. W. G. Wilson, spent part of the field season investigating pyrites mines and prospects in central Ontario, while Mr. A. H. A. Robinson devoted the entire field season to the investigation of pyrites mines and prospects in other parts of eastern Canada. The areas covered include all known prospects in northern and western Ontario, as well as localities in Quebec and the Maritime Provinces.

The field work on pyrites was undertaken primarily because the demand for pyrites ores for use in making sulphuric acid for munition purposes was large, and at one time it was feared that there would be an acute shortage of sulphur, a most essential material. It is also proposed to prepare a second edition of the report on pyrites including the latest information obtainable, the first edition being now out of print.

Mention was made in the Summary Report of 1916[1] that Dr. Wilson had been appointed a special investigator to inquire into the position of the chemical industries in Canada, more especially with regard to works established, products made, and raw materials required. Information on most phases of this inquiry has been available to those entitled to it since early in 1916. It has not been possible to prepare a final report on this investigation for publication, owing to pressure of other duties, nor was it considered expedient to publish a final report until the end of the war. As a direct result of the information secured for the preparation of this report this office was in a position to furnish important information to the War Trade Board and to other Government organizations.

Soon after the organization of this Board Dr. Wilson was appointed engineer in charge of pyrites and sulphur, and during the greater part of the year he acted as technical adviser to the board on various matters which arose from time to time, In this connexion it is to be noted that the services of the staffs of the Division of Mineral Resources and Statistics, the Non-Metalliferous Division, and the Chemical Division were also available to the board, and were utilized by Dr. Wilson as required.

On the initiative of the War Trade Board Dr. Wilson, in company with Mr. S. Barr, an engineer in the employ of the Canada Cement Company, made an investigation of the processes in use in the United States in cement plants for recovering potash from the waste flue gases. Part of the month of August, November, and part of December were required for this investigation. It is desired to express appreciation for the courtesy accorded by certain cement manufacturers in the United States, which made it possible for these two gentlemen to inspect eleven out of the fourteen installations now in operation, or in course of erection. It was not considered necessary to visit the three remaining plants because the installations are largely duplicates of those already inspected.

The potash recovery investigation is being extended to include conditions in Canadian operating plants. The confidential information required by the Board is already available. Eventually a short report will be issued on the subject in bulletin form.

[1] Page 8.

During the year the regular office work of the Division was carried on as expeditiously as possible. The library research work has greatly extended the card catalogue of references to the metal mining industries of Canada. It is believed that every important known occurrence of the metals iron, copper, zinc, lead, silver, molybdenum, tungsten, titanium, and several minor metals, including the majority of literature references to the same, has been indexed, chiefly by Miss D. M. Stewart. The library research work carried on in this Division also includes the indexing of all available references to electro-metallurgical processes, air nitrates, potash recovery and production, and several other lines of chemical technology. It is to be noted that this index was started prior to 1914. As a result this office was supplied with the most complete information available on the subjects of electro-metallurgy, air nitrates, and potash recovery, prior to the commencement of the war.

In continuation of the work on iron ore resources of Canada, Mr. Robinson prepared a bibliography and abstracts with respect to occurrences and commercial utilization of titanium. Additional abstracts on Canadian iron ore deposits, supplementary to the information contained in the Report on the Iron Ore Occurrences in Canada, were also prepared. A large scale reference map for office use, showing the location of all the occurrences of iron ores in Canada and their relation to lines of transportation, is also in course of preparation.

II.

INVESTIGATION OF PYRITES RESOURCES.

A. H. A. Robinson.

The field season of 1918 was spent in an investigation of the undeveloped pyrites resources of eastern Canada, viz., Ontario, Quebec, New Brunswick, and Nova Scotia. The greater part of the season was spent in Ontario; the ground covered in that Province embracing all the northern and northwestern portions, except the district along the Algoma Central Railway, north of Sault Ste. Marie. The deposits along the Algoma Central, and those in southeastern Ontario, were to be examined by other investigators. In the main, attention was confined to prospects that are within a reasonable distance of existing lines of transportation, either rail or water.

Instructions were to obtain as detailed information as possible regarding each prospect visited, paying particular attention to its physical condition, its location with respect to transportation facilities, and its present ownership; this information being required, primarily, for the use of the War Trade Board, and, secondarily, for the preparation of a second edition of the Mines Branch report on Pyrites in Canada. Occurrences of pyrrhotite were also to be noted.

Very little prospecting or development work was going on in any of the localities visited. On most of the properties no work had been done for some time—often years, and such openings as still exist were in anything but good condition for satisfactory examination. Many of the openings, also, had been made to explore, not for pyrites, but for deposits of other minerals with which the pyrites happened to be associated. The only information that could be gathered concerning some of the deposits was that afforded by an examination of old rock dumps or natural outcrops. When the latter, as is usually the case with pyrite and pyrrhotite, are more or less deeply weathered nothing very definite can be learned as to the probable quality of the unaltered mineral beneath.

Samples, for analysis, were taken from most of the deposits examined. In taking them, an effort was made to choose only such material as could be regarded as being probably fairly representative of a considerable portion of the deposit; but this was seldom possible, not only on account of the smallness of many of the exposures accessible for sampling, but also because the only available source was usually shallow pits or old dumps, in both of which the pyrites had been subjected to more or less weathering. Samples taken under these conditions can, therefore, only be regarded as indicating in a very general way the probable composition of the main body of the deposit.

Many of the prospects visited have already been examined and reported on by competent and reliable observers. As these previous examinations were, in many instances, evidently made at a time when the showings were in much better condition for examination than they are now, earlier reports have been freely drawn upon and frequently quoted verbatim—with due acknowledgment to the authors—in writing the descriptions of the individual deposits.

The only prospect visited in Ontario where development work was actually being carried on was at Nickel lake; where a shaft had just been started on an outcrop of pyrites of excellent grade, for the purpose of determining its extent underground.

At the Whelan and Cross property, on Minnitaki lake, where high grade pyrites has also been found, a shaft was sunk, and the deposit cross-cut at a depth of 75 feet, in 1916-17. At this stage development was stopped; the somewhat unfavourable situation of the deposit with reference to transportation facilities having, apparently, discouraged, for the time being, any further expenditure in opening it up.

In 1917 the General Chemical Company, of New York, did considerable drilling to explore pyrites deposits south of Mokomon, in Conmee township, apparently with results satisfactory to themselves, for they subsequently took over the property under long term lease. No start has yet been made to develop the property, however.

Extensive deposits north of Rush lake, though at present somewhat inaccessible and perhaps of interest for their iron content rather than for sulphur, are nevertheless worthy of note. The expulsion of the sulphur would render much of the material in these deposits suitable for the production of iron in the blast furnace; an end that might possibly be economically attainable by saving the sulphur as a by-product. Extensive deposits at Atikokan also may ultimately be made available by some such method of treatment.

In Quebec, up to the present, all the producing pyrites mines and practically all the known prospects that show any promise of becoming of economic value are found in the Eastern Townships, and have been described in detail by J. A. Bancroft in a "Report on the Copper Deposits of the Eastern Townships in the Province of Quebec," issued by the Quebec Bureau of Mines, in 1915. Since Bancroft's report was written some further exploration by diamond drilling and surface prospecting has been done on a number of the old properties, but, so far as could be learned by inquiry at the Provincial Bureau of Mines in Quebec and by a visit to the mining districts of the Eastern Townships, this has not resulted in any new discoveries or developments of especial interest.

In the Maritime Provinces—New Brunswick, and Nova Scotia—there is no record of pyrites ever having been mined in commercial quantities for its sulphur content. There is, however, no geological reason why deposits of commercial value should not be found there; occurrences of pyrites, often associated with copper and gold, are reported at a number of places in both provinces. After interviewing individuals familiar with the known mineral occurrences in the Maritime Provinces and consulting the provincial authorities at Fredericton and Halifax, visits were made to what were considered to be the most promising localities; but nothing was found, or could be heard of, that gave any indication of probable value as a commercial source of pyrites.

Among the deposits inspected were the nickeliferous pyrrhotites found near St. Stephen, N.B., which are of improved, but probably limited extent.

Throughout the season information, wherever sought, was cheerfully and freely given, and acknowledgment is due to all those prospectors, mining men, government officials, and others too numerous for individual mention, who, sometimes at considerable inconvenience to themselves, volunteered to act as guides, or rendered other service with unfailing courtesy and kindness.

PYRITES PROSPECTS IN NORTHERN AND NORTHWESTERN ONTARIO.

Deposits Accessible from the Canadian Northern Railway: Fort Frances to Sudbury.

FURLONGE LAKE.

Furlonge lake is situated about 35 miles in a straight line north of Fort Frances; and about 10 miles north of Manitou sound, the north end of the north arm of Rainy lake.

Drummond Claims: J.L. 150, J.L. 151, F.F. 240 and F.F. 255.

These four mining claims, including in the aggregate some 170 acres of land and land under the waters of Furlonge lake, are owned by Drummond Mines, Limited, Mark Fisher building, Montreal. The following information regarding them, taken from the company's records, has kindly been supplied by its president, Mr. Geo. E. Drummond.

The claims can be most conveniently reached from Fort Frances by taking a gasoline boat to the Cascades at the head of Manitou sound, a distance of about 34 miles. From the Cascades there are two available canoe routes to Furlonge lake: one, by way of the Manitou river, is about 15 miles in length, but owing to the number of portages it takes a day to make the trip without a load; the other, by way of Six Mile, Echo, Smoke, and Kaiarskons lakes, is about 12 miles in length, and can be travelled in five hours, going light. The second route is the one usually taken.

Up to the present only a small amount of development work has been done on the property, but four lenses of pyrites, having the following surface dimensions, are known to occur:—

No. 1 lens	118 by 30 feet.
2 "	110 " 24 "
4 "	50 " 13 "
6 "	60 " 14 "

The sulphur content of average samples from the different lenses is said to run as follows:—

No. 2 lens	41·62 per cent
4 "	40·68 "
6 "	37·63 "

There are good indications that other pyrites bodies occur on the claims.

The situation of the property makes the question of transportation a serious one. The following method of getting the output to the railway has been proposed, should the deposits be worked: from the mine at Furlonge lake to Kaiarskons lake, one-third

of a mile, by aerial tramway; across Kaiarskons lake, 4 miles, by barge; from Kaiarskons lake to the Devil's Cascade, 7 miles, by aerial tramway; from the Devil's Cascade to Fort Frances, 30 miles, by barge—making a total of 41½ miles by combined barge and aerial tramway. At the various transhipping points ore bins would be built and the ore transferred to and from the barges by whirlies and clams.

The Nickel Lake Iron Range.—The Nickel Lake iron range is a belt of banded iron formation rocks that can be traced by its iron-stained, gossan-bearing outcrops along the Canadian Northern railway, across the townships of Watten and Halkirk, from the east shore of Rainy lake to Bears Passage. The most abundant constituent of the iron formation is silica, occasionally interbanded with magnetite, but oftener charged with pyrites and pyrrhotite, especially the latter. A few outcrops, however, show only massive iron pyrites, and the occurrence of these affords ground for the hope that bodies of pyrites will be found, large enough and pure enough to be valuable as a source of sulphur. Exploration has been undertaken at several points along the range in search of such workable deposits of pyrites.

Brunette's Claims: K. 206.

These claims, the property of Chas. Brunette of International Falls, Minn., are situated in the township of Watten, on the west side of the entrance to Rocky Islet bay, one of the many arms of Rainy lake. The iron range here lies a short distance north of the Canadian Northern railway track, near mile board 224. The deposits are, therefore, favourably situated with regard to transportation facilities.

Considerable trenching and test pitting has been done, and prospect openings are to be found scattered along for a quarter of a mile or more across the property. Most of them were started through drift and are now partly filled with water and mud washed in from the top and sides. Except what could be inferred from an examination of the excavated material lying alongside them, they furnish little information as to what had been uncovered at the bottom; the little that was seen would indicate that further exploration of the deposits was warranted.

The first trench inspected is on the shore of the entrance to Rocky Islet bay, just opposite the mouth of a little gully running inland from the sandy beach. Heavy dark brown limonite and pieces of rather coarsely granular, friable pyrites, apparently broken out of the partly leached surface of a large body, were found beside this trench. Excepting a little intermixed quartz, no impurities could be detected in the lumps of pyrites, which, so far as could be judged by eye, is of good quality.

Inland from this trench there are some shallow pits along the rocky right hand bank of the gully. These show light brown and yellow mixtures of limonite with sandy silica and clay, and cellular quartz left by the leaching out of sulphides. No unaltered pyrites or pyrrhotite was found around the pits to indicate that the leached zone had been passed through in them. Indications point to the bottom of the gully as a likely place in which to look for a body of sulphides; but no pits or trenches were found there, probably because the gully serves as a local drainage channel, and the soil in the bottom is so saturated with water that digging pits or trenches in it would be a difficult matter.

Most of the work on the claims has been done still farther inland where, to judge by the excavated material scattered around numerous pits, trenches, and prospect shafts, the iron formation is made up largely of a mixture of pyrrhotite and pyrites, of which the former is much the more abundant.

In November, 1918, these sulphide deposits were being explored by diamond drilling, for the Grasseli Chemical Co.

Wallace Claims: F. 85 and F. 86.

J. A. Wallace of Fort Frances is the recorded holder of these two mining claims, which are situated on the Canadian Northern railway, in lots 11 and 12 of the south range, concession II, township of Watten. They were being prospected, just south of the railway near mile board 216, by C. B. Stranahan, of 65 Wall street, New York, in July, 1918.

Here trenching through stratified clay had disclosed three roughly parallel bands of interlaminated rock and pyrites in the underlying, folded iron formation. The pyritous bands follow the general trend of the enclosing rock which strikes approximately west. The two northerly bands are each about five feet wide; the southerly band, about seven feet; the greatest width of clean pyrites seen in any of the bands, however, would not exceed twelve inches. Their length had not been determined. Pyrrhotite is associated with the pyrite in the most northerly band.

A small trial shipment of pyrites, picked from mixed material blasted out of the trenches, is said to have been made during the summer.

All work was stopped in August, 1918.

The Nickel Lake Mining Co.: P. 577, P. 580, G. 616 and G. 617.

Mining locations P. 577 and P. 580 take in the narrow strip of land between Nickel lake to the north and Grassy Portage bay to the south, on lots 7 and 8, concession II, of the township of Watten; the Canadian Northern railway runs southwestward across the locations following the lake shore closely. G. 616 and G. 617 cover the adjoining land under the waters of Nickel lake. All four locations, together with others in the immediate vicinity, are owned by the Nickel Lake Mining Co., Ltd., McIntyre Block, Winnipeg, Man.

The rock on the east and south shores of Nickel lake is lean siliceous iron formation consisting, for the most part, of fine granular quartz, with which is interbanded varying, but small, amounts of low grade magnetite. Along the south shore of the lake it carries, also, large quantities of iron sulphides—pyrrhotite and pyrites. The west shore of Nickel lake consists entirely of a dark, massive, basic eruptive rock classified by Lawson[1] as hornblende-gabbro. Similar basic rock penetrates the pyritous iron formation at places on the south shore and may possibly have some genetic connexion with the pyrrhotite and pyrite so abundant there.

Massive iron pyrites—free from pyrrhotite—outcrops close to the water's edge on the south shore of the lake, where a shaft is now being sunk. The band, or lens, of pyrites is about 12 feet wide where it is exposed and strikes approximately west, parallel to the iron formation in which it is enclosed. The dip is to the north at a high angle. Along the strike the band disappears into the lake, leaving only about 50 feet of its length exposed.

The six feet of pyrites that constitutes the north half of the band is practically pure except for a little intermixed silica. It is coarsely crystalline, granular, and friable. Analysis of an average sample taken across this part of the outcrop shows the sulphur content to be 46·06 per cent, and silica 9·11 per cent; a picked sample yielded sulphur 48·03, iron 43·43, insoluble residue 5·05, zinc 1·03, arsenic 0·012 per cent.[2] The pyrites on the south side is mixed with more or less interlaminated carbonaceous slate, or schist, and thin sheets of granular white quartz. Black, carbonaceous schist forms the south wall of the deposit; the north wall is quartzite. Along the north wall in places, are patches of a conglomerate made up of rounded and subangular pebbles of granular quartz and grey banded chert embedded in a cement iron

[1] Lawson, A. C., "The Archean Geology of Rainy Lake Re-studied," G.S.C., No. 24 Geological Series, pp. 36-40, 1913.

[2] H. A. Leverin, analyst.

pyrites. A similar conglomerate, or breccia, in which, however, the cementing material, instead of being pyrites, is a mixture of pyrrhotite, quartz, and a little chalcopyrite, outcrops about a quarter of a mile away on a tiny islet near the northeast shore of the lake.

In all probability the mining locations surrounding Nickel lake were first taken up under the erroneous impression that the pyrrhotite found there carries nickel in economic quantity. Dr. Coleman[1], who examined the Nickel lake iron range in 1901, mentions the outcrop of pyrites on the south shore of the lake, and suggests the possibility of future value as a source of sulphur. Some diamond drilling, to test the extent of this iron pyrites deposit, was done in 1902, when the property was under option to Cleveland, Ohio, parties. No information is available as to the results of the drilling, but the option was dropped, and nothing more was done to develop the property until the present owners commenced active operations in 1918. Early in the summer of that year a shaft was started on the pyrites outcrops and by November had reached a depth of 22 feet. Sinking was hampered, however, by the lake water coming in through fissures in the rock. To obviate this difficulty, a concrete collar is now being built, and the upper portion of the shaft lined with concrete. It is proposed to sink to a depth of eighty feet and then drift east and west from the shaft to ascertain the length of the ore-body.

The equipment on the property consists of two small boilers, a Lidgerwood hoist, a pump, and steam drills. The buildings include a two story cooking and sleeping camp for the men, a manager's residence, stables, warehouse, and blacksmith shop.

As a shaft is within a hundred feet of the main line of the Canadian Northern railway, there will be no difficulty in providing shipping facilities.

Mr. R. H. Flaherty is manager in charge.

Lot 2, Concession III, Watten Township.

Iron range rocks also outcrop about a mile northeast of Nickel lake, on lot 2, in the third concession of Watten township, where considerable areas of heavy gossan occur on the hills north of mile board 214 on the Canadian Northern railway. No work of any account appears to have been done on these outcrops, and no exposures could be found that would furnish a clue to the nature of the underlying deposits.

According to the inscriptions on the corner posts, the ground has been staked as mining claims by J. A. Wallace, of Fort Frances.

STEEPROCK LAKE.

Steeprock lake is north of Atikokan station, a divisional point on the Canadian Northern railway, 141 miles west of Port Arthur. The country surrounding it has received considerable attention from prospectors as possibly containing large bodies of iron ore; search for the latter has been pretty thorough in the vicinity, one result being the discovery of pyrites deposits of considerable extent.

Mackenzie and Mann Locations: A.L. 460, A.L. 461 and A.L. 462.

Mining locations A.L. 460, A.L. 461, and A.L. 462 are situated on the west side of Steeprock lake, about 3 miles north of the Canadian Northern railway track.

The following extract is taken from a report made by Charles Camsell, in 1903, to the owners, Messrs. Mackenzie and Mann. It has been made available for publication through the courtesy of Mr. F. S. Wyley, of Port Arthur, the agent for the property:—

[1] Eleventh Annual Report of the Ontario Bureau of Mines, p. 134, 1902.

"The pyrite vein . . . has been traced through locations A.L. 460, 461, and 462. Three holes have been put down to cut the vein at a depth of from 50 to 100 feet . . . They are now drilling on a fourth hole and if they strike the vein there again they will have a known length of over 600 feet. The vein can be traced from the north end of A.L. 460 southward through 461, and it outcrops again on the north and west shores of a small lake in A.L. 462. Where the drill holes cut through it, its width is from 6 to 13 feet. In the south half of A.L. 461 it dips down into a large swamp in which no trace of it can be seen, but it can be picked up again south of the line. The walls of the vein are composed of a soft graphitic slate or shale, and next to this on either side are chloritic schists, phases of which are sometimes very siliceous and always pyritous. To the west the schists grade imperceptibly into a calciferous quartzite. The vein usually occupies a depression in the ground, and on its surface the iron has been dissolved out by the action of water carrying organic acids, and deposited on the slope of the hill to the south in the shape of limonite. There is a great deal of quartz in the vein rock, which shows up well after the iron and sulphur have been extracted. The percentage of quartz on the hanging-wall is not nearly so great as on the foot-wall. The sulphur content is high enough to make the property valuable, and the only objection is the small size of the vein."

Five holes were drilled all told. The following particulars concerning them have also been supplied by Mr. Wyley:—

No. of hole.	Length of hole.	Length in pyrites.
1 on A.L. 461	157 feet	6 feet.
2 " "	167 "	11 "
3 " "	120 "	13 "
4 on A.L. 460	195 "	21 "
5 " "	161 "	11 "

*In hole No. 5 the pyrites was so soft that it stopped the drill, and the full width was not penetrated.

Analyses of drill core samples, E. B. Kenrick, Analyst.

—	% Iron.	% Sulphur.	% Phosphorus.
Core from hole No. 2—foot-wall	39·4	44·2	Trace.
" " 2—hanging-wall	43·2	48·8	"
" " 1— "	41·7	47·7	"
" " 1 foot-wall	38·4	43·8	"

There has been nothing done to develop the deposits since they were drilled, in 1903-4.

Strawhat Lake: Mining Locations 857 X. and 858 X.

A quarter of a mile west from the south end of the southeast arm of Steeprock lake is a small lake named Strawhat lake which forms part of mining locations 857 X. and 858 X. The pyrites deposits are to be found at the southern extremity of Strawhat lake. The distance to Atikokan station is 4 miles southwest by level road.

The locations, which are said to be controlled by the United States Steel Corporation, were explored for iron ore, by diamond drilling, in 1902-3, and again in 1909. The drilling done in 1902-3 showed "siliceous iron formation with pyritic bands;" that done in 1909 "limonite in chert associated with pyritic greenstone and chlorite schists."[1]

[1] Iron Ore Occurrences in Canada, Mines Branch Publication No. 217, 1917, Vol. II, p. 52.

W. G. Miller,[1] who saw the deposit when it was being uncovered in 1902, says: "The pyrite is more or less mixed with rock matter and magnetite, and has a brecciated appearance."

The occurrence is described by E. L. Fraleck, in the Sixteenth Report of the Ontario Bureau of Mines, p. 173; and as nothing that adds to the information contained in his report has been done on the property since, it may be quoted verbatim:—"A very large deposit of iron pyrites has been uncovered at the southern extremity of Strawhat lake . . . The work done comprises trenching, test pitting, and four diamond drill holes on locations 857 X and 858 X. The south trench shows a width of pyrite of over 140 feet, the eastern 60 feet of which would be quite high grade at shallow depth, as the only impurity was gossan. The ore showed unequal banding and nodular weathering. The eastern portion of the trench is somewhat siliceous, and would not run more than 38 to 40 per cent of sulphur. A test pit 100 yards to the north, near the camp, shows very fine pyrites under a heavy capping of limonite and hematite. The hill on which the south trench is located is thirty feet high, and the whole gully to the west appears to be underlain with pyrite. Diamond drilling disclosed the pyrite in the form of a vast crescent, between the horns of which lies a deposit of hematite . . . . . . The country rock to the west is an eruptive greenstone, and to the east green schist. Those along the trail to Steeprock lake show at times a curious ellipsoidal weathering."

THE ATIKOKAN IRON RANGE.

Between Atikokan and Kawene stations, on the Canadian Northern railway, bodies of magnetite associated with much sulphide of iron, usually in the form of pyrrhotite but sometimes as pyrites, have been found strung out along the valley of the Atikokan river for a distance of about 16 miles. This iron-sulphur bearing belt, known as the Atikokan iron range, is broken topographically by Sabawe lake into an eastern and a western portion. On the western portion of the range the mixed sulphides consist almost entirely of pyrrhotite, but on the eastern end, at Atikokan mine, there are large bodies of mixed magnetite and pyrites.

Much of the material in these deposits would satisfy all the requirements for a good iron ore were it not for the high percentage of sulphur it contains; the sulphur content, on the other hand, is not large enough to make it valuable for the recovery of sulphur alone. A course of procedure in which the sulphur, expelled by roasting, would be saved as a by-product may ultimately solve the economic problem of utilizing material of this composition for iron ore. The extent of the deposits, and of others of somewhat similar composition at Rush river—to be described later—makes a solution of the problem involved in their utilization especially desirable.

It is possible also that investigation would show that, by careful selection, pyrites of merchantable grade could be produced from some of the deposits at Atikokan mine. Up to the present they have been looked upon as a possible source of iron ore only.

West of Sabawe Lake: R 403 and 212 X.

Magnetite-pyrrhotite deposits are found within half a mile north of mile board 134 on the Canadian Northern railway. They lie just south of Atikokan river, on mining locations R 403 and 212 X.

The only exposure of the iron-bearing formation on 212 X is in a pit near the west boundary, where a considerable body of pyrrhotite has been uncovered. Farther west, on location R 403, numerous trenches and test pits have been dug, exposing,

[1] Twelfth Report of the Ontario Bureau of Mines, 1903, p. 309.

in most cases, irregular lenses of mixed magnetite and pyrrhotite. The width of the area within which these lenses occur is approximately 100 feet; its total length on the two locations, as determined by magnetic survey, is 2,900 feet.

In 1908 and 1909, considerable exploration, by trenching, test pitting, and diamond drilling, was done on the deposits, under the supervision of R. H. Flaherty, of Port Arthur. D. B. Rockwell, the engineer in charge of the work, estimates that there has been proved up 2,530,000 tons of material of the following average composition:—

Iron	59·80 per cent.
Silica	3·30 "
Sulphur	20·40 "
Phosphorus	0·025 " *

West of Sabawe Lake: 138 X and 139 X.

The magnetite-pyrrhotite deposits on mining locations 138 X and 139 X are about 500 feet north of the Canadian Northern track, between mile boards 135 and 136; practically all the deposits are on location 138 X

Iron-bearing formation is exposed in numerous places along a high ridge which extends from mining location 139 X westward across 138 X. In it the mixed magnetite and pyrrhotite is found concentrated in irregular lenses, or pockets, and also disseminated through the rock. In samples taken from the surface exposures the sulphur content ranges from 3 to 25 per cent; iron, from 38 to 62 per cent; silica, from 2 to 16 per cent; and phosphorus from 0·006 to 0·045 per cent.

A magnetic survey of the two locations shows that the iron formation on them occupies an area 2,600 feet long and about 250 feet wide at the widest place. Exploration by surface work and diamond drilling, done in 1908 and 1909 under the supervision of R. H. Flaherty of Port Arthur, has proved up, it is estimated, 1,827,000 tons of material of the following composition on location 138 X alone:—

Iron	55·73 per cent.
Silica	6·67 "
Sulphur	20·38 "
Phosphorus	0·037 " †

East of Sabawe Lake; Atikokan Iron Mine.

On the eastern end of the Atikokan iron range considerable pyrites, mixed with magnetite, is found in the Atikokan iron mine. The mine is a little less than a mile east of Sabawe lake; a spur line, 3 miles in length, connects it with the main line of the Canadian Northern railway at a point 128 miles west of Port Arthur. The Atikokan Iron Company of Port Arthur is the owner.

The iron range rocks outcrop on mining locations E 10 and E 11, forming a steep, narrow ridge, 3,800 feet long, having a maximum width of 400 feet, and an elevation above the surrounding swamp of nearly 100 feet. The ridge is made up of interlaminated greenstones, green schists, and roughly lenticular bodies of magnetite, some of which are highly pyritous. In portions of some of the lenses in the south side of the ridge, pyrites is the most abundant constituent.

At the mouth of a tunnel driven north through the west end of the ridge, there is a band, or lens, of irregularly banded pyrites and magnetite, 7 feet wide, and having the following average composition:—

Sulphur	18·81 per cent.
Iron	48·26 "
Silica	6·06 "
Phosphorus	0·009 "

* Iron Ore Occurrences in Canada, Vol. II, Mines Branch Publication No. 217, 1917, p. 46.

† Iron Ore Occurrences in Canada, Vol. II, Mines Branch Publication No. 217, 1917, p. 46.

Twenty-seven feet in from its mouth the tunnel passes through a second lens, or band, 26 feet wide, and carrying an average of:—

Sulphur	14·93 per cent.
Iron	45·10 "
Silica	4·90 "
Phosphorus	0·064 "

About 950 feet east from this first tunnel, No. 1 shaft—47 feet deep—has been sunk at the foot of the ridge on its south side. It is said to have passed through material of the following average composition:—

Sulphur	19·93 per cent.
Iron	55·33 "
Silica	4·46 "
Phosphorus	0·105 "

Pyrites, magnetite, pyrrhotite, and a little chalcopyrite, can be seen mixed with the rock matter in the dump.

One thousand six hundred feet east from No. 1 shaft a second tunnel, driven north into the ridge, cuts 9 feet of mixed pyrites and magnetite carrying:—

Sulphur	25·75 per cent.
Iron	57·33 "
Silica	3·94 "
Phosphorus	0·015 "

No. 3 shaft is close to the mouth of this second-mentioned tunnel; a cross-cut driven north from the shaft, at a depth of 126 feet, passes through 35 feet of mixed pyrites carrying:—

Sulphur	15·80 per cent.
Iron	48·84 "
Silica	12·52 "
Phosphorus	0·23 "

All the analyses given above represent average samples taken across considerable widths of the deposits to determine their value as iron ore. Had the sampling been confined to the more highly pyritous sections only, to determine the existence or otherwise of bodies of pyrites of workable size and merchantable grade, a considerable higher percentage of sulphur could doubtless be shown. A sample of pyrites picked off the dump at the mouth of the tunnel at the west end of the ridge, for instance, yielded on analysis:—(H. A. Leverin, analyst.)

Sulphur	25·41 per cent.
Iron	48·00 "
Insoluble	16·48 "
Zinc	0·31 "
Copper	0·10 "
Arsenic	0·007 "

Conmee Township.

A number of mining claims have been taken up for iron pyrites, on lots B, C, and D, in the fifth concession of Conmee township, about a mile south of Mokoman, a station on the Canadian Northern railway, 31 miles north of Port Arthur.

The pyrites in all the deposits examined is closely associated with banded cherts, jaspers, and magnetite, of the iron formation so abundant in this township. On account of the heavy covering of drift and the generally wooded character of the country, natural exposures are comparatively few, small and hard to find, and prospecting is difficult. The associated iron formation, however, being magnetic, serves to some extent as an indicator, and the dip needle has been successfully used for locating bodies of pyrites hidden under the drift.

All the known deposits are within three-fourths of a mile of the railway.

The North Half of Lot B, Con. V: Morrison Claims.

In 1901, a shallow prospecting shaft was sunk, by the Davis Sulphur Ore Co., of New York, on a deposit of pyrites that outcrops in the bed of Brulé creek near the northeast corner of lot B, con. V, Conmee township. The shaft is now fallen in, but there is a recently dug trench close to it, in which the deposit could be seen.

The trend of the deposit appears to be to the southwest. Some of the pyrites is fairly clean looking, but most of it is mixed with fine-grained silica. Along the edge of the pyrites there is a band of brecciated granular silica. Banded chert, jasper, and magnetite, of the iron formation, outcrop a little farther up the creek. The only other rock seen in place in the immediate vicinity was greenstone. The deep drift covering the bottom of the creek valley precludes any extensive examination of the deposit.

E. B. Fraleck,[1] who examined the occurrence at the shaft in 1906, says:—

"The deposit strikes northeast near the contact of conglomerate and the Mattawin iron range. A deep covering of bouldery gravel obscures the surface, and the deposit can only be examined where a small pit has been sunk on the bank of Brulé creek. The bottom of the test pit is 5 feet below the level of the creek, and about 80 tons are on the dump. The pyrite-bearing zone appears to be about 30 feet wide.

"The occurrence is one of replacement, wholly or in part, of the conglomerate by pyrite, which even when massive retains that structure. The more soluble pebbles have been completely replaced by pure pyritic nodules with a roughly spherical outline. In the other portions of the conglomerate the substitution is more or less incomplete, the pebbles of pure silica being entirely unchanged.

"An average sample of ore on the dump yielded 29·20 per cent of sulphur."

Mr. Bruce L. Morrison, of Port Arthur, is the present owner of this property.

The North Half of Lot B, Concession V: The General Chemical Company's Claims.

Immediately south of the Morrison claims—and also on the north half of lot B, concession V—are two mining claims that are now under lease to the General Chemical Company, of 25 Broad street, New York. They are located on the northern edge of the heavily wooded high land that bounds the south side of the valley of Brulé creek. The Canadian Northern railway passes half a mile east of them.

A large amount of trenching, test pitting and stripping has been done on these two claims, but when they were visited, in 1918, most of the workings had become useless for purposes of observation, through the caving in of earth from the sides. In one stripping, pyrites with some included rock matter is exposed over a width of 70 feet. Another exposure, some distance to the northeast, consists of 25 feet of mixed gossan, leached rock capping, and pyrites. Magnetite and pyrrhotite occur locally, mixed with the pyrites. Lean siliceous magnetite, very similar to some of the magnetite found in the iron formation, is also found as angular and sub-angular fragments enclosed in pyrites, usually towards the edge of the deposits.

The deposits were diamond-drilled in 1917 by the General Chemical Company of New York, who are the owners of pyrites mines at Northpines, Goudreau, and Sulphide, Ontario, and of chemical works at several points in Canada. The drilling is reported to have proved the existence of bodies of pyrites of workable size and merchantable grade, and apparently the results were satisfactory to the company as they subsequently leased the property for a term of years on a royalty basis.

No visible preparation is yet being made to develop the deposits.

The Matheson Claims.

Adjoining Morrison's and the General Chemical Company's claims on the north, east, and south, there are a number of other claims on which pyrites deposits have

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[1] Sixteenth Annual Report of the Ontario Bureau of Mines, 1907, p. 172.

been reported to occur. They have a multiplicity of owners, but W. A. Matheson, barrister, of Fort William, is more or less directly interested in all of them.

Mining Location R. 702 takes in the southern portion of lot C, concession VI. In 1913 or 1914, a diamond drill hole was put down near the southwest corner of the location to test at depth the iron formation that outcrops a little to the west. Pyrites is said to have been found in this hole, but authoritative information is lacking.

North Half of Lot C, Concession V. On the southern portion of the north half of lot C, concession V, a number of trenches have been dug through drift near the west boundary of the lot. Pyrites is said to have been found in some of them, but the trenches are now fallen in, so the statement could not be confirmed.

The Morton Lease. What is sometimes known as the Morton Lease constitutes the northwest quarter of the south half of lot C, concession V.

Near the northwest corner of the claim there are two old prospecting shafts and, between them, a stripping 30 or 40 feet in diameter. The general trend of the workings is north and south. The south shaft is just at the edge of the stripping and is now filled with debris. The other shaft is about 50 feet north of the stripping, and higher up the hill; it is about 20 feet deep.

A section across the stripping shows 2 feet of pyrrhotite; 6 feet of mixed pyrites and pyrrhotite; 15 feet of mixed pyrrhotite and rock; and 12 feet of pyrites with some intermixed silica. On the uphill side of the stripping the sulphides are overlain by about eight feet of mixed granular quartz, leached rock capping, and impure limonite.

At the bottom of the north shaft there is about eight feet of pyrites mixed with some quartz. The upper part of the shaft is in a gossan of leached rock and limonite. The material on the dumps contains both pyrites and pyrrhotite.

Lot B, Concession V. On the northeast quarter of the south half of lot B, concession V, lumps of iron pyrites enclosing fragments of fine-grained magnetite were picked up alongside some caved-in trenches.

In a stripping near by, a seam of pyrites, two to three feet thick, occurs in a twelve-foot band of rusty quartzose rock that lies between porphyritic greenstone and banded iron formation.

South Half of Lot C, Concession V. Near the middle of the south half of the south half of lot C, concession V, some shallow pits have been sunk in a zone of rusty gossan-bearing rock. The pits are now partly filled with loose earth and gossan, and no unweathered formation can be seen in them. Mingled with the rock matter on the dump, however, there is a considerable amount of fine-grained, mixed pyrites and magnetite.

Crumpled, cherty, banded iron formation lies east of the rusty, pyritous rock; between the two is a curious breccia, made up of shattered iron formation cemented by magnetite and quartz.

Lot D, Concession V. On lot D, concession V, a triangular, fractional lot bounded on the northeast by the Kaministikwia river, large boulders of clean pyrites "float" have been found in the bed of the creek that flows into the river from the southwest. Attempts to trace them to their source have been, so far, unsuccessful.

LAKE NIPIGON.

Mike Ralph's Claim: T.B. 3423.

This prospect can be reached by a trail a mile and a half long that leads southeastward from the railway bridge that crosses the Blackwater river a mile and a half west of Jackpine. Jackpine is a station on the Canadian Northern railway, 135 miles east from Port Arthur.

Mike Ralph of Port Arthur is the recorded holder of the claim.

A rusty belt of pyritous chlorite schist, or fahlband, crosses the claim in a westerly direction. A small pit, about four feet in diameter and three feet deep, where the fahlband crops out as a low, narrow ridge in a swamp, represents all the work done on it. The surface of the ridge, which is about 60 feet wide, consists of rusty, fissile schist and a little gossan. The pit shows partially weathered pyrites interlaminated with a bright green, fissile, chlorite schist underlying about 18 inches of gossan. The dip of the formation is nearly vertical. Crystals of magnetite are disseminated through the chlorite schist, and the fahlband as a whole has a noticeable effect on the dip needle.

A sample of pyrites from the pit bottom yielded:—[1]

Sulphur	22·9	per cent.
Iron	41·5	"
Zinc	1·6	"
Insoluble	12·6	"

Sudbury District.

RUSH LAKE IRON RANGE.

The Woman River iron range is a belt of iron-bearing rocks that starts at a point near the northeast end of Sahkatawichtah, or Rush lake and runs southwestward across the Rush river and along the Woman and Ridout rivers, for a total distance of about 40 miles.

On that part of the range that lies east of the Rush river, cherty banded iron formation of a usual type is accompanied by, and at places is in contact with, a parallel belt of iron-stained siliceous rock that is heavily charged with magnetite, pyrrhotite, pyrites, and carbonate of iron. A section from north to south across the strike of the iron range here, is as follows:—

Interlaminated greenstones and green schists and some light-coloured acidic schists.

Banded iron formation, largely composed of chert and red jaspery quartz—locally garnetiferous and always magnetic.

Greenstone—wanting in places.

A zone of mixed quartz, magnetite, pyrrhotite, pyrites, and ferruginous carbonates.

Light coloured schists, interlaminated with some darker, green schists—locally garnetiferous.

Basic dikes cut the whole series, which stands nearly vertical.

The Rush Lake deposits are of large extent. Like those on the Atikokan range, they are to be regarded essentially as possible future sources of iron ore, the economic availability of which may ultimately depend on the utilization of the large sulphur content, as well as the iron, thus making the sulphur pay at least a part of the cost of its elimination from the ore. The cost of merely expelling the sulphur to make an ore suitable for use in the blast furnace, is too costly an operation to be profitable, at the present time at least.

Smith Claims: Jefferson Iron Mine. All the known exposures on the Woman River iron range east of Rush river are included in some twenty-two mining claims owned by W. E. Smith of Sudbury. Starting from the east bank of Rush river, these claims extend northeastward in a continuous chain for about 4 miles, across the unsurveyed territory between Sahkatawichtah lake to the south and the townships of Dale and McOwen to the north. They are numbered consecutively, from east to west, W.D. 715 to W.D. 736.

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[1] H. A. Leverin, analyst.

The distance from W. D. 715, at the eastern end of the chain of claims, to Stackpool station on the Canadian Northern railway is about 14 miles in a straight line; by canoe route the distance is about 20 miles—with nine portages. A longer route, but with fewer portages, starts at the Canadian Northern railway bridge over the Groundhog river (Kukatush station) and proceeds by way of Groundhog and Horwood (formerly Matagaming) lakes to W. D. 736, where the western end of the chain of claims touches the Rush river.

Except for a few short intervals, the band of iron formation, and the accompanying sulphide-bearing zone have been traced, in numerous trenches, test pits, and natural outcrops, for the full length of the chain of claims. The line of exposures runs in a general southwesterly direction over low, rocky hills, separated by drift covered flats; the exposures are confined to the hills where the drift covering is thin or lacking. The rusty, pyritous zone—as distinguished from the cherty banded iron formation—averages perhaps 40 feet, and attains a maximum of about 150 feet, in width. It is made up of magnetite, pyrrhotite, pyrites, quartz, and ferruginous carbonates, and includes varying amounts of interlaminated rock.

The relative proportions in which the different minerals occur vary greatly in different parts of the sulphide-bearing zone. On the easterly claims the predominant constituents are magnetite and pyrrhotite, with subordinate quantities of pyrites, carbonate, and quartz. On the western claims magnetite and pyrrhotite are less abundant and, as the Rush river is approached, are almost or entirely lacking, and the deposits become essentially a mixture of pyrites, ferruginous carbonate, and silica.

Intermixed galena, zinc blende and a little chalcopyrite have been found associated with the iron minerals at two places on W.D. 717, near the eastern extremity of the range. The occurrences are both in the magnetite-pyrrhotite zone, near its southern border; they are 500 feet apart, one in a drill hole, the other in some test pits. In one pit mixed galena, blende, pyrites, pyrrhotite, quartz, calcite, and chalcopyrite have been exposed for a width of 15 feet, about 8 feet of which is fairly pure galena and zinc blende. The galena-blende-chalcopyrite mixture appears to occur as a separate deposit cutting the magnetite-pyrrhotite; whether the two exposures of galena and blende are connected by a continuous deposit, or line of deposits, has not been determined.

Analyses of three samples of mixed magnetite, pyrrhotite, and pyrites from the eastern end of the sulphide belt are as follows:—

No.	% Iron.	% Sulphur.	% Silica.	% Phosphorus.
1	43·17	44·16	13·15	
2	52·50	29·64	4·65	
3	52·24	13·62	4·60	0·007

Samples Nos. 1 and 2 were selected for the relatively large amount of pyrites they contained. Sample No. 3 is more nearly representative of the general run of the deposits at this end of the range.

Three samples of mixed pyrrhotite, magnetite, pyrites, and probably a little iron carbonate, from three different trenches on W. D. 731, on the westerly section of the range, yielded:—[1]

	4 %	5 %	6 %
Sulphur	25·94	22·92	34·78
Iron	42·81	43·11	44·79
Insoluble	1·20	4·50	6·40
Phosphorus	0·005	0·006	0·009
Zinc	0·37	0·54	0·25
Arsenic	0·009	0·005	0·009

[1] H. A. Leverin, analyst.

A sample showing pyrrhotite, magnetite, pyrites, and quartz, taken from a stripping near an old shaft on W. D. 732, yielded:—[1]

	7. Per cent.
Sulphur	26·18
Iron	43·50
Insoluble	8·36
Phosphorus	0·015
Zinc	0·10
Arsenic	0·009

The samples of which the two following analyses, 8 and 9, were made, came respectively from W. D. 734 and W. D. 736, near Rush river. In so far as could be seen with the naked eye, they consist entirely of pyrites, iron carbonate, and a little quartz. No magnetite or pyrrhotite could be detected in them, and at the places they were taken the deposits have no effect on the dip needle:—

	8. %	9. %
Sulphur	25·43	30·56
Iron	42·42	43·50
Insoluble	1·78	3·06
Phosphorus	0·011	0·009
Zinc	0·44	0·93
Arsenic	Trace.	0·011

A considerable amount of diamond drilling has been done on the eastern claims, and at two points 1,700 feet apart the deposits have been proved to maintain their surface width at depths of 300 and 380 feet respectively.

The total quantity of mixed sulphides, magnetite, and carbonate on the property is, unquestionably, very large.

Township of Norman, Concession VI.

Some outcroppings of iron pyrites that have been found associated with banded iron formation about 2 miles northwest of Wanapitei lake, in concession VI, of the township of Norman, were visited, in company with Mr. Gilbert Bennett of Sudbury. They lie 5 or 6 miles east of the main line of the Canadian Northern railway; a spur line to the Whistle nickel mine terminates about 2 miles southwest of them.

Gossan outcrops associated with banded iron formation, greenstones, and greenstone conglomerate can be traced from a point on the north bank of Post creek, near the boundary of the Indian reserve, northward to the south boundary of Parkin township. Near the creek, weathered, gossaniferous rock can be seen for a width of 80 feet in some old prospecting pits and trenches. A sample of pyrites mixed with a black material, probably impure magnetite, and some pyrrhotite was taken from one of the old pits and analysed, yielding:—[1]

	Per cent.
Sulphur	34·62
Iron	41·34
Insoluble	4·65
Zinc	0·25
Copper	....
Arsenic	0·004
Phosphorus	0·015

Pyrites, mixed with quartz, was seen in another pit something over half a mile north of the creek, near the boundary of Parkin township. One side only of the deposit has been uncovered, exposing six feet of the mixed material. A sample from this pit yielded on analysis:—[1]

	Per cent.
Sulphur	32·51
Iron	32·80
Insoluble	21·12
Zinc	0·30
Copper	....
Arsenic	0·017

[1] H. A. Leverin, analyst.

The presence of carbonates was indicated in both samples by their effervescing strongly in dilute hydrochloric acid.

Other strippings and shallow pits on the gossaniferous zone show only a little pyrites, pyrrhotite, and impure magnetite scattered through the rock.

Deposits Accessible from the Canadian Pacific Railway: Kenora to Sudbury.

LAKE OF THE WOODS.

Deposits of iron pyrites extensive enough to be of prospective economic value are mentioned by A. C. Lawson[1] as occurring on the shore and islands of the Lake of the Woods.

Ptarmigan Bay.

On the shores of Zig-zag point and Corkscrew island in Ptarmigan bay, there are some bands of black slaty schist, rarely more than 15 or 20 feet wide, of which the "essential character varies from a slightly carbonaceous variety of glossy hydromicaceous slate to a black, argillaceous slate, which soils the fingers on handling. These carbonaceous schists are characterized by two features that have never been found wanting in them wherever observed. They are: a well defined vesicular structure, and an abundance of pyrite. The vesicular structure is so strongly developed in some portions of the schist that it presents the appearance of a very scoriaceous slag, the vesicles ranging in size from cavities an inch or more in diameter to those of quite minute dimensions. . . . The smaller cavities, under a quarter of an inch in diameter . . . are very generally filled with round balls of iron pyrites, which, with a little patience, can be pricked out of the schist in handfuls. . . . In the same schist pyrites is often present in large vein-like masses of such extent as to be of prospective economic value."

Pyrrhotite deposits of considerable size are described by A. L. Parsons[2] as occurring a little west of the Lake of the Woods, near the Ontario-Manitoba boundary.

Shoal Lake.

"At mining location M.H. 7, near the mouth of Carl bay, on the south side of Shoal lake, a vein, consisting almost entirely of pyrrhotite, is found outcropping on the shore of the lake. The vein is about 12 feet wide and is between walls of altered trap. . . . So far as seen, no work of any account has been done.

At the east end of Carl bay a pyrrhotite vein was found about four feet wide near the contact of the granite and altered trap. A small test pit had been sunk, but work has been discontinued."

West Hawk Lake.

South of Ingolf "pyrrhotite runs in two or more parallel bands nearly east and west, and is found extending from a point two or three miles east of West Hawk lake to a point several miles west of the west end of the lake. Much of the rock with which the pyrrhotite is associated is schistose, and resembles the iron formation near Dryden, except that the iron present is combined with sulphur rather than oxygen. The width of the pyrrhotite bodies varies considerably, but in one place east of West Hawk lake the main body was about 150 feet wide, while the rock accompanying it appears to

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[1] Lawson, A. C., Geol. Surv., Can., Annual Report, 1885, pp. 58 and 124 CC.

[2] Twentieth Annual Report of the Ontario Bureau of Mines, 1911, pp. 168 and 197.

be well impregnated with it for a width of several hundred feet, as evidenced by the rusty character of its outcrop. The body of pyrrhotite carries gold values; nickel has been looked for, but up to the present only very small percentages of this metal have been detected by analysis."

Rochon Claims: D. 704 and D. 707.

Mining claims D. 704 and D. 707 are about 2½ miles south of the town of Keewatin, and within half a mile of the west shore of Rat Portage bay of the Lake of the Woods. They were originally staked for gold and are now held by Boromee Rochon, of Keewatin.

On the north part of D. 704 a somewhat pyritous, rusty zone occurs in a belt of light coloured porphyritic schist and schistose agglomerate that strikes a little north of east. Some shallow excavations expose bands three or four feet wide, rather heavily impregnated with pyrites, in the rusty schists; but there is nothing that suggests the possible presence of workable deposits of that mineral.

Farther south on the same claim an old shaft, said to be 32 feet deep, has been sunk in the side of a hill facing southeast. The shaft is now full of water. There is considerable gossan in the vicinity of the shaft, and massive pyrites and pyrrhotite can be picked out of the rock matter in the dump. Impure limonite, probably derived from pyrrhotite and pyrite in the rocks on the hillside above, occurs in considerable quantity on the low ground at the foot of the hill.

D. 707 lies immediately south of D. 704. In a trench 132 feet long, dug across the top of a knoll, on D. 707, there is little to be seen but leached rock and gossan. Pieces of mixed pyrrhotite, pyrites and rock can be found in the excavated material alongside the trench.

Two hundred and fifty or three hundred feet southwest of the trench a shallow open-cut in the southwest face of the hill has been excavated, for the most part in leached rock capping; a little solid pyrrhotite and pyrite can be seen in it, however. Judging by the look of the gossan, any unweathered sulphides found beneath it are likely to be badly mixed with rock matter.

Pyrrhotite also occurs east of D. 704 and D. 707, near the shore of Rat Portage bay, on the property of a Mr. Gagnon.

Guthrie Claims.

On page 175 of the Sixteenth Annual Report of the Ontario Bureau of Mines, 1907, E. L. Fraleck describes three mining locations, A. 274, A. 257, and A. 273, as being located on a fahlband a mile and a half north of Riddell siding on the Canadian Pacific railway.

There is no longer a Riddell siding on the railway, and the only claims in the locality described by Fraleck that are now on record in the Mining Recorder's office at Kenora are S. 772, S. 773, S. 774, and S. 775, lying east and south of Octopus lake, staked by Dave Guthrie, of Kenora. Pine station, on the Canadian Pacific railway, is about a mile and a half south of them.

No work is now being done, and there is nothing further of interest to add to Fraleck's description of the locality, which is as follows:—

"A heavy fahlband strikes in a northeast direction along a range of bare hills. In all the valleys and depressions along the range high grade limonite is found. Some of this may have resulted from the decomposition of pyrites in place, but for the most part it has been derived from oxidation along the hills and subsequent deposition in the depressions. It was impossible to arrive at the depth of the limonite, but the surface area was quite extensive. No high grade gossan was observed in place on the hills, and the fahlband was, in the main, low grade. A small test pit, however, near

the shore of a lake disclosed promising gossan and very fair pyrite. The country rock is a felsitic schist, cut by numerous pegmatite dikes. It is said that later operations have disclosed a considerable body of mixed pyrite and pyrrhotite."

EAGLE LAKE.

The Canadian Pacific railway skirts the shore of Eagle lake at Vermilion bay, 56 miles east of Kenora. Eagle River station, 10 miles farther east, is 4 miles from Eagle lake, with which it is connected by a river of the same name, and also by road. The river is navigable from the lake to within a mile of the station.

Net Island.

Net island is situated near the west shore of Eagle lake; 10 or 12 miles from Eagle river, and 15 or 16 miles from Vermilion bay.

The occurrence of pyrites is mentioned by A. L. Parsons,[1] who examined the island in 1911. He says: "The greater part of the interest in mining in this region has been connected with a vein near the northern part of Net island, which has been looked upon as an iron deposit. During the previous winter this vein was tested by diamond drilling, stripping, and the sinking of a small shaft. The vein as it is exposed varies from 4 to 12 feet in width, and on the surface is oxidized so as to present a mixture of limonite with small amounts of hematite and magnetite. Where excavation has been made the vein material has been found to be largely made up of pyrite with small amounts of chalcopyrite. If this vein were better situated with respect to transportation facilities it should prove valuable as a source of pyrite."

When the island was visited in 1918, the shaft was found partly filled with debris. It has been sunk through the gossan capping of the deposit near the top of a low rocky ridge, across which the vein cuts. It is said to be 22 feet deep and still in decomposed matter at the bottom. On the surface, near the shaft, there is 18 feet of gossan between well defined walls. The sides of the shaft show, for the most part, fine granular, porous, residual quartz mixed with limonite. Numerous, discontinuous. vertical streaks of pulverulent magnetite occur through the quartz, and an occasional copper stain is to be seen. There is also a little friable pyrites that has escaped decomposition scattered through the mass. Exceedingly fine-grained, dense, blue-black magnetite of exceptional purity occurs, in places, plastered on the south wall of the deposit in irregular patches up to 4 or 5 inches thick.

The vein can be traced eastward from the shaft, by strong magnetic attraction and occasional outcroppings of dense limonite, to a shallow pit 250 or 300 feet distant, at the foot of the ridge. Here, twelve feet of pyrites lying against the north wall of the deposit is exposed; the south wall has not been uncovered. Quartz and some magnetite are interlaminated with the pyrites in narrow irregular bands.

A sample from this pit yielded on analysis:—[2]

	Per cent.
Sulphur	23·85
Iron	53·23
Insoluble residue	4·82
Zinc	0·44
Copper	0·05
Arsenic	0·007

East of the pit, clay flats extend to the edge of the island, and obliterate any further trace of the vein in this direction. West of the shaft, there are exposures of rusty rocks along the line of strike of the deposits, but no pyrites of importance was seen.

[1] Twenty-first Annual Report of the Ontario Bureau of Mines, 1912, p. 184.

[2] H. A. Leverin, analyst.

The country rock is a bright green, fissile, chlorite schist that appears to grade, in places, into massive greenstone. Crystals of pyrites and of magnetite, up to a quarter of an inch in diameter, are plentifully sprinkled through the schistose wall-rock. The dip of the vein is nearly vertical; its strike, approximately west; both are parallel to the schistosity of the enclosing rock.

A diamond drill hole was put down not far from the shaft to test the deposit at depth, but no authoritative information is available as to the results obtained.

The property is controlled by R. C. Gamble of Ottawa.

North Twin Island.

Half a mile or more east of Net island, and approximately on the line of strike of the Net island vein, a small outcropping of magnetite associated with rusty rock and a little pyrites has been found on the shore of North Twin island. A diamond drill hole put down in the magnetite outcrop is said to have penetrated pyrites at a depth of 50 feet.

ENGLISH RIVER.

Several zones of pyritous rocks, or fahlbands, of considerable extent are known to occur in a belt of Keewatin rocks that lie about 14 miles southwest of English River station (English P.O.), on the Canadian Pacific railway. Numerous mining claims have been staked on them.

Nicuso Syndicate Claims. The Nicuso Syndicate, of 301 Sparks street, Ottawa, has some 20 or 30 mining claims staked on such fahlbands lying between Welsh and Keewatin lakes. The syndicate claims are in two groups: the southerly group surrounds and includes two small lakes, sometimes known as Pine and Cryderman lakes; the northerly group—a short distance north of Pine lake—includes part of a small pond sometimes called Paul Stone's lake.

Pine lake is accessible by a canoe route 20 or 25 miles in length, that, starting at English River station, proceeds by way of Scotch river, Upper and Lower Scotch lakes, and Irish lake to Welsh lake. From the east side of Welsh lake a portage, about two-thirds of a mile long, leads to Pine lake. Trails lead to the northerly group of claims from both Pine lake and the upper end of Irish lake.

A great deal of trenching, test pitting, and stripping has been done on the properties; but, when they were visited, recent heavy rains had converted most of these excavations into mere receptacles for mud and water which effectually concealed whatever had been found in them. A few were in better condition for examination.

Southern Claims.—A pyrite-bearing band of black, carbonaceous rock which crops out on the south shore of Pine and Cryderman lakes, crosses the southern claims in a general westerly direction. A pit on the south shore of Cryderman lake, on mining claim K. 683, is about six feet deep in black graphitic slate heavily charged with pyrites. Only one side of the deposit has been uncovered, exposing about 12 feet of the mixed pyrites and slate. About 250 feet east of this pit, interbanded pyrites and graphitic slate, underlying a capping of vesicular graphitic rock, are again exposed. The exposure is 10 or 12 feet wide, but neither wall has been uncovered. Other trenches and pits in the vicinity were too full of mud and water to permit of an examination being made of them.

The pyrites occurs, in part, as spherical nodules, up to several inches in diameter, filling cavities scattered irregularly through the graphitic slate. In part, mixed with silica, it is interbanded with the graphitic material. Some of the pyritic bands are made up largely of coalescing spherules of pyrites with quartz filling the interstices, but in most of them the pyrites is finely crystalline, granular, and shows no spherical structure.

Samples of (1) the mixed nodular pyrites and pyritous slate; (2) the general run of the banded pyrites; and (3) the purest looking of the banded pyrites, yielded on analysis:—[1]

	1.	2.	3.
	%	%	%
Sulphur	24·7	24·5	30·1
Iron	23·5	23·0	30·0
Insoluble	35·9	45·3	25·7
Arsenic	Trace.	Trace.	Trace.
Zinc	0·84	0·64	0·64
Copper	None.	None.	None.

What is seemingly the same band of black, pyritous schist that is exposed on Cryderman lake outcrops again about three-quarters of a mile eastward, on K. 715. Here, an open-cut into the bank, on the south side of Pine lake, exposes a deposit 12 or 14 feet wide, of mixed graphitic slate, limonite, pyrrhotite, pyrites, and quartz underlying eight feet of dense gossan.

Trenching between the exposures on K. 683 and those on K. 715 is said to have demonstrated the continuity of the pyritous, graphitic rock across the two intervening claims, K. 682 and K. 699. The trenches were not in a condition to afford any evidence on this point when the property was examined, however.

Greenstone and quartzite were the only rocks noted in association with the carbonaceous slate. Drift obscures most of the surface in the vicinity.

Northern Claims.—Near the upper end of Paul Stone's lake, on K. 712, 15 feet of siliceous pyrites interbanded with graphitic slate, or schist, lying alongside ten feet of siliceous banded iron formation, is exposed in a trench and pit. Very little gossan is to be seen. In places the pyrites bands are twisted and contorted, following corresponding twists and contortions in the schist. Some of the bands consist of a string of flattened, coalescing, nodules of pyrites. Small, single nodules also occur sparsely scattered through the banded material.

The pyrites in this pit was the cleanest seen on the northern claims. A sample yielded on analysis:—[1]

	Per cent.
Sulphur	23·84
Iron	22·19
Insoluble	44·64
Arsenic	0·01
Zinc	0·29
Copper	0·30

Iron formation rocks with an accompanying pyritous band can be traced eastward from the pit on to K. 713; and westward across claims K. 711, K. 718, and K. 720. Banded siliceous pyrites, very similar to that on K. 712, is exposed again on K. 718. Iron formation, consisting of alternate narrow bands of chert and magnetite, outcrops near the line between K. 719 and K. 720.

There has been considerable trenching, test pitting, and some drilling done, on K. 720, where the occurrence of iron-stained siliceous rock carrying some pyrrhotite, pyrite and a little chalcopyrite, has caused the expenditure of much fruitless energy in a search for deposits of copper ore.

NORTH SHORE OF LAKE SUPERIOR.

Rossport.

Some of the mining locations originally taken up for gold near Rossport, on the north shore of Lake Superior, have from time to time been mentioned as carrying sufficient pyrites to warrant the expectation that they may develop into pyrites mines.

[1] H. A. Leverin, analyst.

Veins and small pocketty masses of various mixed sulphides are not uncommon in the district, but none were seen, or heard of, that gave any particular indication of being valuable, commercially, as a source of pyrites.

Schreiber.

Some years ago a certain amount of development work was done on pyrites prospects near the north shore of Lake Superior, in the neighbourhood of Schreiber, a divisional point on the Canadian Pacific railway.

Mudge (Otisse) Prospect: Mining Location 776 X.—Mining claims T.B. 1048 and T.B. 1049 constitute, respectively, the northwest and southeast quarters of old mining location 776 X.

The recorded owner is J. D. Mudge, of Schreiber.

A rusty zone, or fahlband, crosses T.B. 1048 in a northwesterly direction. It is said to cross T.B. 1049 also, and to be traceable altogether for a mile or more. Many years ago a few shallow pits were sunk on what is now T.B. 1048. The largest of these is on the hillside south of a valley that runs east from the north end of Cook lake; it is about a mile and a half, or two miles north of Schreiber. The pit is about 12 feet deep and 12 feet long across the strike of the deposit, which here consists of a very fine-grained intimate mixture of pyrrhotite, pyrite, and, probably, magnetite.

A sample selected from the old dump yielded:—[1]

	Per cent.
Sulphur	28·6
Iron	42·5
Insoluble	10·2
Arsenic	0·02
Zinc	1·40
Copper	None.

An average sample of the dump taken by Fraleck,[2] in 1906, yielded 32·26 per cent sulphur.

The Davis Sulphur Ore Company: Mining Location R. 606.—This prospect is about a mile and a half, by good winter road, southeastward from Schreiber.

Fifteen or twenty years ago considerable work was done on it by the Davis Sulphur Ore Company, of 65 Wall street, New York (who are said to be still the owners), and a carload lot of pyrites was sent east for testing purposes. At that time it was purposed, should the deposit prove satisfactory on development, to build a tramway to Lake Superior, and ship the output by way of the Great Lakes.

The old workings consist of a shallow open-cut, or trench, that runs north along the strike of the deposit for about 100 feet; a shaft, now full of water, near the north end of the trench; and a short tunnel driven into the hillside beside a brook at the bottom of a gully below the shaft.

Both pyrites and pyrrhotite occur in the deposit, and there is considerable intermixed quartz. Copper is also said to occur, but no copper minerals were seen. The width of sulphides in the trench varies from 4 to 10 feet. A section from east to west, near the face of the open-cut, is as follows:—

Fine-grained, massive pyrites with some intermixed silica and pyrrhotite	3 feet.
Quartz, with disseminated pyrite and pyrrhotite	1 foot.
Massive pyrrhotite mixed with some rock, and quartz	4 feet.

The dip is to the east, at an angle between 50 and 60 degrees. Black cherty-looking rock forms the hanging wall; the foot-wall rock could not be determined, owing

[1] H. A. Leverin, analyst.

[2] Sixteenth Annual Report of the Ontario Bureau of Mines, 1907, p. 177.

to its altered condition and the drift covering. At the south end of the trench a porphyritic granite dike seemingly cuts off the deposit in that direction.

A sample across 3 feet of the purer looking pyrites on the east side of the trench yielded on analysis:—[1]

	Per cent.
Sulphur	27·48
Iron	41·54
Insoluble	13·40
Arsenic	0·02
Zinc	1·52
Copper	None.

The results of this analysis are not what would be expected from the appearance of the sample submitted.

There is considerable fairly clean looking pyrites on the old stock piles near the shaft, but much of the material is either massive pyrrhotite or rock heavily charged with pyrrhotite.

The dump at the mouth of the tunnel below the shaft consists entirely of black, graphitic slate, or shale, carrying a few small stringers of pyrites.

The Morley Prospect.—Under this heading Fraleck describes a prospect "situated about three miles southeast of Schreiber on the Canadian Pacific railway, and about two miles from the north shore of Lake Superior."[2]

According to J. D. Mudge of Schreiber, the Morley prospect is identical with R. 606, the Davis Sulphur Ore Company's claim just described; a statement that seems to be confirmed by the close correspondence of Fraleck's description with the present appearance of that property.

Mining Location R. 638: Ansell's Claim.—The southwest corner of mining location R. 638 is now held as mining claim T.B. 2381 by J. Ansell of Schreiber.

About 100 yards north of the Canadian Pacific railway track, a mile and a half east of Schreiber, a fahlband, lying between trap on the north and quartzite on the south, strikes westward across T.B. 2381. It dips north into the hill. Some strippings and shallow trenches expose pyrrhotite and small stringers of pyrite mixed through the fahlband rock.

A sample of the best looking of the mixed material yielded on analysis:—[3]

	Per cent.
Sulphur	27·25
Iron	40·06
Insoluble	4·00
Arsenic	0·008
Zinc	0·14
Copper	nil

Mining Location R. 425.—The fahlband that crosses T.B. 2381 outcrops again about a quarter of a mile east, on R. 425, where a short incline driven into the side of the hill north of the railway track exposes a vertical section of the rocks.

The incline is driven in a bed of quartzite that is overlain by trap and underlain by greenstone. A thin layer of pyritous, black graphite slate, or schist, separates the trap from the quartzite. A few small, irregular pockets of friable, granular pyrites occur in the quartzite and accompanying graphitic schist.

East of the incline, there are a number of strippings and shallow pits that show only small stringers of pyrites in the iron-stained weathered rock. The iron stain and gossan so conspicuous on the bare hillside are, in all probability, derived from disseminated pyrites and these small stringers.

[1] H. A. Leverin, analyst.

[2] Sixteenth Annual Report, Ontario Bureau of Mines, 1907, p. 177.

[3] H. A. Leverin, analyst.

Sulphur Lake.—Fourteen miles north of Schreiber, a narrow fahlband, 2 miles or more in length, runs northeastward across Sulphur lake. Veins of pyrites, up to 2 feet wide and carrying low gold values, and pyrrhotite veins up to 3 feet wide occur in it.[1]

Jackfish.

Locations taken up for gold in the vicinity of Jackfish station, on the Canadian Pacific railway, are said to carry pyrites in such quantity as would possibly make them valuable as pyrites mines.

All the gold prospects in the vicinity have been idle for a good many years, and it was not found possible to obtain any information that would tend to confirm this statement.

Schist Harbour.

A mile and a half north of Schist Harbour, which is a few miles east of Jackfish, on the north shore of Lake Superior, Olie Nelson and others, of Fort William, have a number of mining claims, staked on a fahlband.

Narrow bands of fairly clean pyrites occur in it, but no bodies of commercial size and grade have yet been found.

Port Coldwell.

S. D. Crenshaw, of S. D. Crenshaw & Co., Richmond, Virginia, is reported to have an iron pyrites prospect near Port Coldwell, a fishing hamlet 25 miles east of Jackfish.

The property could not be located, nor could any information be obtained concerning it.

MISSINAIBI.

Smith-Travers-Laforest Prospect.

Information concerning this prospect was supplied by Mr. C. H. Hitchcock, geologist to Messrs. Smith and Travers, Sudbury.

The property consists of five mining claims, S.S.M. 1846 to 1850, lying northwest of Lake Manitowick, in township 45, range XXV, Algoma district. The Algoma Central railway runs 8 miles southwest of them.

The claims can be reached by canoe from Missinaibi station, on the Canadian Pacific railway, but Hawk Junction, on the Algoma Central railway, is closer to them.

The owners are T. E. Smith, T. Travers, and L. Laforest, all of Sudbury.

Heavy limonite gossan is found associated with a belt of siliceous, pyrite-bearing, iron formation that lies between acid and basic Keewatin schists. The upper part of the iron formation, next the basic schists, consists of quartz with disseminated pyrites, and, judging by the similarity of the geological conditions to those obtaining at the Goudreau pyrites deposits, is probably the hanging wall of any large bodies of pyrites that may exist. It is a hard formation that stands out on the surface, and so serves as an indicator.

The pyritous quartz formation extends from a small lake, called Pine lake, at the northwest corner of S.S.M. 1847, westward across S.S.M. 1846, and disappears into a swamp on S.S.M. 1849. It is about 1,500 feet long; the width has not been determined.

A second gossan-bearing belt of siliceous iron formation occurs to the north, crossing S.S.M. 1848 and S.S.M. 1850.

The best indications of the occurrence of bodies of pyrites are found in a shallow valley that follows the iron formation westward from Pine lake. Four pits on S.S.M.

[1] R. E. Hopkins, Twenty-fourth Annual Report, Ontario Bureau of Mines, 1915, p. 13.

1846 show compact limonite, but did not reach the underlying formation. A pit to the north, on S.S.M. 1848, shows siliceous iron formation, about half of which is pyrites.

SUDBURY DISTRICT.

Townships of Balfour and Creighton.

Along the northern edge of a low rocky ridge which, running southwestward across lots 6 and 7, concession I, of the township of Balfour, and lots 8 and 9, concession VI, of Creighton, about 3 miles south of the Canadian Pacific railway between Chelmsford and Larchwood stations, forms the southern boundary of the flat clay farm land that fills the Chelmsford basin, the existence of sulphide bodies is indicated by some large gossan-covered areas and the material lying around old prospect workings.

The deposits themselves are no longer accessible in the abandoned workings, and most of the information now available as to their nature is such as can be inferred from an inspection of the dumps. Pyrites, galena, zinc blende, chalcopyrite, quartz, calcite and other carbonates, appear to have formed the vein filling; black graphitic (Onwatin) slate the wall rock. Mottled (Onaping) tuff lies just south.

Some large chunks of clean looking pyrites can be seen on the dumps, and considerable bodies may possibly occur in the old workings or under the unexplored gossan-covered areas; but whatever value the deposits may have would appear to lie in their metallic contents rather than in the sulphur.

Lots 6 and 7, Concession I, Balfour Township: At the old workings on lot 6, concession I, Balfour township, said to belong to George Irwin, of Sudbury, zinc blende and galena appear to have been the minerals found in greatest abundance.

Heavy gossan covers considerable areas on lot 7 to the west.

Lot 9, Con. VI, Creighton Township: The dumps at the old shaft on this lot show mixed pyrites, zinc blende, galena, and chalcopyrite. Some of this material had been sacked for shipment, apparently as copper ore. There are also some large chunks of clean looking pyrites, now crumbling to pieces under the weather.

The property is owned by M. Meehan, of Sudbury, and Alphonse Olier, of Chelmsford.

Deposits accessible from the National Transcontinental Railway: Winnipeg to Cochrane.

VERMILION LAKE.

Vermilion lake is about 5 miles west of the town of Graham, the junction point of the main line of the National Transcontinental railway with the branch line running to Fort William. The discovery, on the north shore of the lake, of the large body of pyrites that was later developed into the General Chemical Company's Northpines mine, led to considerable search being made in the vicinity for other similar bodies. Such deposits as have been found are described by E. S. Moore in the Twentieth Annual Report of the Ontario Bureau of Mines, 1911, pp. 204 to 207.

Tindall Claims.

Concerning these claims he says: "On the east end of an island in Vermilion lake, about eight miles west of Vermilion (Northpines) mine, there is a deposit of pyrite on what is known as Tindall's claims. On this island there is a pit upon a hill a few rods from the shore, in drift about 15 feet thick. In the bottom of the pit there is a vein about 2½ feet wide, composed of nearly solid pyrite. On the south side of the

vein the rock is a schistose quartz-porphyry, containing small crystals of pyrite. The rock on the north side could not be determined because of its altered condition and the drift cover. The drift overlying the pyrite is stained and cemented with iron oxide. . . . .

"At a stripping on the lake shore the pyrite vein varies in width from three to four feet, but is not so pure as in the first pit mentioned. It carries some quartz, and cuts the schistise quartz-porphyry in such a way as to leave no doubt of its vein character. The strike of the vein is about 80 degrees, and this strike would carry it near the small island to the east of the one on which the vein is seen. No pyrite was found in place on this small island, but some iron-stained schist and a block of pyrite, more than 1 foot in diameter, were seen on the south shore. A further projection of the vein would carry it somewhere near the Vermilion (Northpines) pyrite mine, and it is possible that the two veins are located along the same general line of fissuring."

The Fanning Prospect.

Under the heading "The Fanning Prospect," E. L. Fraleck[1] describes an occurrence of pyrites "situated on the shore of Big Vermilion lake, eight miles west of the Michie (now Northpines) mine." In so far as can be learned, the only discovery of pyrites in the locality indicated by Fraleck is that on the Tindall claims, with which the Fanning prospect is probably identical.

Fraleck's description reads:[1] "some trenching through a blanket of boulder clay about 4 feet in thickness has been done at the extreme end of a point. High grade pyrite, in seams from 2 to 6 feet in thickness, is interbanded with graphitic shale. The deposit strikes east and west, and dips towards the shore to the north."

Mining Claim H.W. 762.

About three-quarters of a mile east of the Northpines mine, four pits have been sunk through drift on mining claim H.W. 762. The drift is stained with gossan, but no pyrites of importance is to be seen in place. A little banded quartz and magnetite occurs in one pit.[2]

Schmidt Claims: H.W. 778 and H.W. 779.

Mining claims H.W. 778 and 779 are about 4 miles northeastward from Northpines mine, close to the railway southwest of Pelican lake.

E. S. Moore says of them:—[3]

"On claims H.W. 778 and 779 there are some pits and trenches. The pit on H.W. 778 is about eight feet deep and runs into the side of a hill. The sulphide consists chiefly of pyrite, with a little pyrrhotite. In spots the pyrite is almost solid, but in other places it is much mixed with rock, either greenstone or altered quartz-porphyry, and an altered granite dike about one foot wide is associated with the deposit. It looks as if the sulphides, accompanied by a granite dike, had come in along a line of weakness between the acid and basic rocks.

"The pit on H.W. 779 is situated, with reference to the last pit described, in a line along the strike of the rocks. This pit is three feet deep by five in diameter and located on a mass of pyrite in schistose quartz-porphyry. Neither of these deposits has yet shown any claim to economic importance."

Some diamond drilling is said to have been done on these claims since Moore's report was written, but no authoritative information could be obtained on this point.

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[1] Sixteenth Annual Report, Ontario Bureau of Mines, 1907, p. 177.
[2] E. S. Moore, Twentieth Annual Report, Ontario Bureau of Mines, 1911, p. 207.
[3] Twentieth Annual Report, Ontario Bureau of Mines, 1911, p. 207.

MINNITAKI LAKE.

Minnitaki lake lies east of Vermilion lake and south of Graham. The Fort William branch of the National Transcontinental railway runs about 4 miles from the east shore, on which the pyrites deposits have been found.

Cross and Whelan Prospect.

The Cross and Whelan property comprises seven mining claims on the east side of Minnitaki lake, not far from the mouth of Minnikau river. It includes a point of land projecting westward into the lake from the east shore, the north part of Cranberry island, and the land under the waters of the lake adjacent to both point and island. The prospect is accessible by water from Graham, 10 miles northwest.

W. A. Cross and Jas. Whelan, both of Port Arthur, are the owners.

The outcrop of the deposit, on the lake bottom close to the north shore near the end of the point, is entirely covered with water; a knob of pyrites projecting through the ice at a time of low water led to its discovery. The rock on the shore adjacent to the outcrop is a grey, sericitic schist, through which a little pyrites is disseminated. South of the sericitic schist is green chlorite schist. The rock dips north, toward the lake, at an angle between 60 and 70 degrees; the strike is westerly. Development work shows that the dip of the pyrites is parallel to that of the schist.

A shaft, which is now full of water, has been sunk close to the shore—on mining claim K 608—directly opposite the outcrop in the lake. According to Mr. W. A. Cross, the shaft is 75 feet deep, and a cross-cut 80 feet long has been driven north from the bottom. At a point 50 feet from the shaft, the cross-cut entered mixed pyrites and rock, and, after passing through 10 feet of this mixed material, penetrated clean massive pyrites for 20 feet. The face of the cross-cut was still in clean pyrites when it was stopped, at a point 80 feet from the shaft, in November, 1917. There are about 100 tons of clean pyrite that should run over 40 per cent of sulphur on the dump at the shaft mouth.

Four shallow drill holes, spaced at intervals for about a mile along the strike, have also been put down to test the deposit. One, put down beside the shaft on K. 608, at an angle of 45 degrees, is said to have cut 80 feet of pyrites. Assuming the dip of the deposit to be 65 degrees, this 80 feet would correspond to a thickness of about 35 feet, measured at right angles to the walls.

A second hole, on K. 628, the next claim east, also pointing north at an angle of 45 degrees, is said to have passed through 18 feet of pyrites.

The third hole, still farther east, on K. 627, cut soft, pyritous, graphitic schist; but no solid pyrites.

The fourth hole was put down on K. 629, west of the shaft, on the northwest shore of Cranberry island. It is said to have cut four feet of pyrites.

Much more development work would appear to be well warranted on this prospect; that more has not been done appears to be almost entirely due to its, at present, somewhat unfavourable location with respect to transportation facilities.

STURGEON LAKE AREA.

Hornick Prospect.

R. S. Hornick, of Allanwater P.O., Ontario, is the owner of three mining claims, T.B. 2201, 2356, and 2357, located on a band of pyritous rock that strikes northward along the west shore of Loch Gordon, a small, narrow lake whose northern extremity touches the National Transcontinental railway, a mile east of Staunton section house.

The rocks in which the pyritous band is found, are mapped by the Geological Survey as fissile biotite and hornblende-gneisses, and arkose, occupying an intrusive contact zone between Keewatin and Laurentian rocks.[1]

[1] Geol. Sur., Can., Map No. 993, 2nd. Ed., 1909.

The best exposures of the pyritous band are at the south end of Loch Gordon, on mining claim T.B. 2201. Here, heavy gossan outcropping along the west shore can be traced north into a swamp on T.B. 2357, and south into T.B. 2356. Numerous trenches have been dug in the iron-stained drift and honeycombed quartz that cover the deposit, but in few of them could unaltered formation be seen. Pyrites and pyrrhotite, mixed with more or less quartz, are to be found on the dumps. The dip of the rock varies from vertical to 40 degrees, west.

At the bottom of one pit, about 10 feet deep, there is 5 feet of pyrites mixed with a little quartz against the hanging wall, and about 8 feet of a poorer mixture of pyrites quartz and rock on the foot wall. A sample taken across the 5 feet of pyrites on the hanging wall yielded:—

	Per cent.
Sulphur	43·21
Iron	40·10
Insoluble	1·31
Arsenic	Trace.
Zinc	0·31
Copper	0·63

A second, parallel belt of iron-stained rock runs up the west side of T.B. 2201.

KOWKASH GOLD AREA.

In a report on "The Kowkash Gold Area," published in the Twenty-sixth Annual Report of the Ontario Bureau of Mines, 1917, pp. 223 to 225, P. E. Hopkins describes a number of occurrences of pyrites and pyrrhotite in that district.

The following extracts are taken from Hopkins' report:—

Whitefish Lake.

"A prospector, Phillip Gagnon, discovered a pyrite deposit, five miles to the southwest of Paska station, on the south shore of the extreme northeast end of Whitefish lake. The pyrite occurs about 300 yards south of a syenite hill, in black slates of the iron formation type, which strike southwest and northeast. Under three feet of water, and about fifteen feet from the shore, are two places which show massive pyrite, apparently of good quality and over a width of four feet. It grades, at the sides, into black slates covered by gossan in places and containing much disseminated pyrite, often in the form of rounded nodules. Some magnetite and pyrrhotite and a little chalcopyrite are also present in parts of the formation. The deposit warrants further exploration."

Lake Ste. Marie.

"A wide iron formation band of varying strike and dip occurs in the rhyolites around lake Ste. Marie, which is two miles to the southeast of Redmond station. The rocks have been greatly brecciated, permitting the circulation of sulphide solutions . . . Within 100 yards of the northeast shore of the lake, trenching has revealed a pyrite band 3 feet in width. A chipped sample across three feet yielded, on assay, 31·3 per cent of sulphur and $2.40 of gold to the ton. There was not enough work done to disclose the extent of the deposit."

Coleman Deposits.

"D. Coleman, a prospector, has located a pyrite deposit one-quarter of a mile north of mileage 55·7 on the railway. At this locality on the side of a large hill of cherty-looking rhyolite, is a vein-like deposit five feet in width containing considerable pyrite. . . . About 100 yards west of the pyrite showing, and on the south shore of a pond is a massive pyrrhotite body, five feet or more in width, from which samples gave, on assay, no values in gold, platinum or nickel."

McCann Claims.

These claims, T.B. 2808, 2809, 3,060, and K. 115, owned by J. C. McCann, of Kowkash, are 3 miles north of Paska station.

Hopkins says: "Mr. McCann has done several hundred feet of trenching near the III-mile post of Code's meridian line to Howard falls, in an endeavour to locate a pyrite deposit. The stripping has revealed gossan in the form of rusty sand and limonite below which is considerable pyrite and a mixture of pyrite and pyrrhotite, somewhat interbanded, in a cherty quartz-porphyry and altered iron formation. The deposit across 50 feet would run about 20 per cent of sulphur, there being a much larger amount of lower grade material. A sample of the massive sulphides contained no gold or nickel."

Willet Lake.

"Pyrite was discovered by the writer on the small pond four chains east of the east end of Willet lake. . . . The pyrite occurs disseminated through a "sugary" quartz-schist which strikes N. 70° W. and dips vertically. Ten feet of the deposit would run about 25 per cent of sulphur; a sample showed gold to be absent. If some trenching were done in this vicinity a workable pyrite deposit might be located."

Pyrrhotite Deposits.

Several large bodies of massive pyrrhotite occur in different parts of the district. In so far as they are known, they carry neither gold, nickel nor platinum, and are of no commercial importance.

"The largest body seen lies on the south central shore of *Marshall lake,* where an open-cut through shallow gossan reveals fifteen feet or more of pyrrhotite which contains a small amount of pyrite and quartz. . . . A mile and three-quarters northeast of Marshall lake, near *Lower Meta lake,* considerable work has been done on a rusty hornblende-mica schist containing much disseminated pyrrhotite."

A sample from a pit eight feet deep, three-quarters of a mile east of the eighty-fourth mile post on the east boundary of the Nipigon Forest Reserve, consists "largely of pyrrhotite with some pyrite and magnetite, an altered iron formation."

A pyrrhotite mass has been found also at *Rupert falls,* on the Kawashkagama (Kowkash) river.

Deposits Accessible from the Timiskaming and Northern Ontario Railway: North Bay to Cochrane.

Timagami Bay to Cochrane.

In a report on "Iron Ores of Nipissing District," W. G. Miller[1] draws attention to the possible future value, as sources of sulphur, of certain belts of pyrite-bearing rock that are found running roughly parallel to the iron ranges in the vicinity of Lake Timagami. The distance separating the pyritous belt from its accompanying band of iron formation is usually less than half a mile.

Some of the localities in which Miller reports such pyrites-bearing belts to occur are: *Snake lake, Turtle lake, Matagama point, Vermilion lake, O'Connor lake, Net lake, Heart lake, Kokoko lake, Austin bay, Cross lake,* and *Emerald lake.*

A sample of the pyrites in a pyritous band south of O'Connor lake yielded, on analysis, 35·91 per cent sulphur, and $1.20 in gold per ton; another, from the south shore of Vermilion lake, 30·31 per cent sulphur and $2 in gold per ton. A third sample, of mixed pyrites and rock, from the south shore near the eastern extremity

[1] Tenth Annual Report of the Ontario Bureau of Mines, 1901, pp. 160-180.

of the northeast arm of lake Timagami gave 26·2 per cent sulphur, 0·48 per cent copper, 0·27 per cent nickel, and $1.40 in gold per ton.[1]

O'Connor Prospect.

Mining claim W.D. 357, in the township of Strathcona, owned by J. T. O'Connor, of Sudbury, has been located on one of these pyritous bands, as a copper prospect. This prospect is on the south shore of the northeast arm of Timagami lake, about 2½ miles from Timagami station.

The pyritous band, which also carries pyrrhotite and a little chalcopyrite, can be traced northeastward across this claim and the next two claims to the east—W.D. 402 and W.D. 401; it parallels a band of iron formation that runs through Turtle lake, north of the northeast arm. The country rock is greenstone and green schists. In many places a felsitic looking rock—possibly ryholite—occurs on the foot-wall side of the pyritous zone. The dip is northwestward at varying, but usually low, angles.

Not far from the lake shore, on W.D. 357, there are seven or eight pits and open-cuts, from which some 1,000 tons of ore are said to have been taken; 542 tons are said to have been shipped to Grasselli Chemical Company's works at Hamilton in 1916. As seen in the pits, pyrites and rock are irregularly intermixed, widths of from four to six feet of fairly pure looking pyrites being accompanied by rock matter heavily charged with pyrites. Judging by its appearance, most of the material would require considerable culling to make a merchantable grade of pyrites.

A sample of the best looking ore taken from one of the piles yielded:—[2]

	Per cent.
Sulphur	39·40
Iron	43·55
Insoluble	11·55
Copper	1·17
Zinc	1·57
Arsenic	0·009

Analyses furnished by Mr. J. T. O'Connor, the owner, show: sulphur 20·12 to 39·4 per cent, copper 0·78 to 5·4 per cent, and 0·03 to 0·05 oz. gold per ton.

In the winter of 1916-17 eight diamond drill holes, aggregating 1,000 feet of drilling, were put down in the vicinity of the pits. Six of these are said to have passed through pyrites five to thirty feet thick. The drill cores were not analysed.

Test pits along the strike of the fahlband, on the east side of W.D. 357 and on W.D. 402, also show some fairly clean pyrites mixed with rock heavily charged with pyrites. A sample from one of these pits near the east boundary of W.D. 357 yielded:—[2]

	Per cent.
Sulphur	28·21
Iron	32·26
Insoluble	8·12
Copper	1·20
Zinc	1·47
Arsenic	0·007

Mandy Claim.

A deposit of pyrites occurs in the township of Cassels, a short distance inland from the east shore of Outlet bay of Net lake, on what is known locally as the Mandy claim, which in so far as could be ascertained, is identical with mining claim T.R. 1229.

Shallow pits and trenches, scattered over an area about 100 feet in diameter, disclose an irregular deposit, of undetermined extent, of mixed pyrites and quartz in

[1] W. G. Miller, Tenth Annual Report, Ontario Bureau of Mines, 1901, p. 180.

[2] H. A. Leverin, analyst.

greenstone country rock. Some of the pyrites, which is fine-grained and massive, is quite clean looking, though most of it is mixed with considerable quartz. The unaltered pyrites is overlain by a thin capping of gossan and cellular leached quartz.

A sample of some of the better looking pyrites from one of the pits yielded, on analysis:—

	Per cent.
Sulphur	44·58
Iron	42·64
Insoluble	9·45
Arsenic	Trace.
Zinc	0·49

Northland Pyrites Mine: James Lake.

The Northland Pyrites mine, also known as the Rib lake, James lake, or Harris mine, is situated on the shore of James lake, about 10 miles north of Timagami station. A spur line, half a mile long, formerly connected the mine with the Temiskaming and Northern Ontario railway.

The deposit, discovered in 1903, was not developed until 1906, when shipment of pyrites commenced, and was continued with few interruptions until July, 1910, when the mine was abandoned, and the plant afterwards removed. No work has been done since 1910. The last two months before closing down, the mine was operated under lease from the owners—The Northland Mining Company of London, Ontario—by C. B. Stranahan of New York.

At the time of its abandonment the shaft had reached a depth of 300 feet, and levels had been driven at 100, 175, and 275 feet. On the first level, drifts had been carried 150 feet north and 250 feet south of the shaft; on the second level, 165 feet north and 200 feet south. Stoping had been done above all three levels. The stopes between the first and second levels were from 10 to 20 feet wide. In addition to that won from the underground workings, considerable pyrites was also mined from open-cuts southeast of the shaft. Most of the output went to Buffalo, N.Y.

The deposit in which the main shaft was sunk was a lens-shaped body enclosed—in a rusty belt, or fahlband—in soft green schist, about 100 feet east of its contact with a grey hornblende granite. The dip of the deposit, and of the enclosing schist, is west, at an angle of about 70 degrees. The only impurities in the pyrites were some small veinlets of quartz, and, in places, finely disseminated pyrrhotite. Massive pyrrhotite occurred on both walls of the lens.

Other lenses of pyrites have been found in the same pyritous zone, or fahlband, which is fairly strong and traceable for a quarter of a mile or more.

BOSTON TOWNSHIP.

Whelan Prospect.

Mr. P. Kirkegaard, Sun Life Building, Toronto, did some work during the summer of 1918 on a pyrites prospect, known as the Whelan claims, situated 2¾ miles east of Dane station on the Temiskaming and Northern Ontario railway. The workings are about 600 feet south of the road from Dane to Larder lake, on mining claim L. 7069, the northwest quarter of the south half of mining location M.R. 14, Boston township.

Here, the trees and brush have been cleared from an area about 150 or 200 feet square; the rock surface partly stripped, and several test pits sunk. The pyrites, mixed with much quartz, is found associated with a black, cherty, pyritous banded rock resembling iron formation, and greenstone, both of which are cut by small trap dikes. Acid eruptives also occur in the immediate vicinity; and the rocks appear to

have been much disturbed and altered. There are some pyrrhotite and magnetite in places. The mixed pyrites and quartz, as seen in the exposures, is in seemingly discontinuous bodies scattered without apparent order over the cleared area. Bands, or probably pockets, of pyrites, from a few inches to seven or eight feet thick, were measured in the various openings. Some small spherical nodules of pyrites, as well as disseminated crystals, are to be seen in the black chert.

The material in the ore piles is pyrites mixed with considerable quartz and some pyrrhotite. A general sample from one of the piles yielded, on analysis:—

	Per cent.
Sulphur	41·03
Iron	37·39
Insoluble	19·60
Arsenic	0·01
Zinc	0·20

About 100 feet north of the clearing, beside the trail leading to the Dane-Larder Lake road, a pit 10 by 20 feet has been dug about 14 inches deep in drift stained a deep red by iron oxides which may either have been washed down from the rocks exposed in the clearing, or have been derived from sulphides in place.

HEARST TOWNSHIP.

Two pyrites prospects in the township of Hearst are described by P. E. Hopkins, of the Ontario Bureau of Mines, in "The Canadian Mining Journal" for February 5th, 1919, p. 71, as follows:—

Mining Claim H.S. 904.

"A promising pyrite prospect occurs on Claim H.S. 904, or No. 2717 on Sharp creek, one-half mile from the southwest bay of Larder lake, in Hearst township. This is one patented claim of a group owned by the Combined Larder Mines, Ltd., in which James Hales, barrister, Imperial Bank Building, Toronto, is interested. The claims were extensively prospected near the surface for gold several years ago, but apparently with little success. In October, 1918, the writer, while examining some of the old workings, noticed that a mineral dump on the above claim, H.S. 904, consisted almost entirely of massive iron pyrites with some gossan. The shaft was full of water, but the owners reported the shaft to be 25 feet deep, with a 25-foot cross-cut at that depth, all of which were in pyrite. The dump consists mainly of fine-grained, massive pyrite with occasional quartz and dolomite stringers carrying a little pyrrhotite and magnetite. An eight pound sample which was fairly representative of the dump yielded on analysis 43·00 per cent of sulphur and 40 cents of gold to the ton. About 100 yards northwesterly from the dump, with intervening drift covered surface, is a deposit of "sugary" quartz, and 100 yards farther along the same strike is a 30-foot shaft in a banded formation of "sugary" quartz with much pyrite and pyrrhotite. The rocks in the vicinity are dominantly green chlorite schists and pillow lavas. The deposit is apparently worthy of further development. It lies 12 miles distant from the Temiskaming and Northern Ontario Railway, and 1½ miles from the Associated Goldfields hydro-electric transmission line."

Mining Claim H.S. 913.

"Massive iron pyrite several feet wide was also seen in a 6-foot pit on claim H.S. 913 in the southeast part of Hearst township."

EBY TOWNSHIP.

Feick Prospect.

The Feick pyrites prospect is on the southwest quarter of the north half of lot 2, concession III of the township of Eby, 3½ miles due south of Kenogami station on the Temiskaming and Northern Ontario railway. It can be reached from Swastika, 5 miles distant by bush trail.

Harry O. Feick, of Kitchener, Ont., is the owner.

The rusty, weather surface of a fahlband striking northward has been uncovered over a length of 1,000 feet or more, and a number of trenches and test pits dug in the altered rock. One pit, 10 feet deep, in a gossan of limonite and cellular quartz, shows in the bottom a width of 10 feet of massive pyrites with some intermixed quartz. A sample taken for analysis yielded:—

	Per cent.
Sulphur	40·91
Iron	36·82
Insoluble	20·41
Arsenic	0·015
Zinc	0·20

The rocks in which the fahlband occurs are Keewatin: greenstones, schists, and iron formation. Intrusive syenite occurs a short distance to the east.

MAISONVILLE TOWNSHIP.

In the Twenty-third Annual Report of the Ontario Bureau of Mines, Part II, p. 34, A. G. Burrows says:—

"On lot 7, in the third concession of Maisonville the iron formation is much fractured and impregnated with iron pyrites, pyrrhotite and a little copper pyrites. A sample of pyrrhotite, on analysis, showed a trace of nickel. The rock in the vicinity is greatly oxidized, and this locality is worthy of prospecting for iron pyrites."

PORCUPINE AREA.

Bobs Lake Prospect.

A pyrites deposit of such extent as to have attracted attention to its possible economic value, outcrops on the south shore at the east end of Bobs lake, on lot 7, in concessions III and IV, Whitney township; about three-quarters of a mile east of South Porcupine station on the Porcupine branch of the Temiskaming and Northern Ontario railway.

The pyrites occurs in a band of siliceous iron formation that can be traced from the lake shore southwestward for a quarter of a mile. Associated with the iron formation are green schists interlaminated with acid eruptives, of which some of the latter are porphyritic. Diabase dikes cut all these rocks, pyritous iron formation included. On the lake shore, the dip of the pyritous band is to the northwest at an angle between 40 and 50 degrees; farther inland the dip becomes steeper.

In part the pyrites is massive and tolerably pure-looking, but most of it is finely disseminated through quartz. Pyrrhotite occurs with it in places. The best exposures are to be seen in three shallow pits, or open-cuts, on the lake shore; other pits farther inland along the strike show, for the most part, only gossan or lean iron formation. The width of the pyritous band could not be determined with certainty, but fourteen feet of the mixed pyrites and quartz are exposed at one place on the shore.

Of the following analyses (1) represents a sample of the purer portions of the band, (2) a general average of the exposure.[1]

	1. Per cent.	2. Per cent.
Sulphur	44·33	29·68
Iron	43·78	34·88
Insoluble residue	7·84	20·30
Zinc	0·10	0·54
Arsenic	0·007	0·009

In the winter of 1916-17 three diamond drill holes were put down through the ice, to explore for the deposit under the east end of the lake—on lot 6, concession IV. The two westerly holes are said to have penetrated pyrites, but no authoritative information is available as to the results obtained.

Moyer Veteran Claim.

About a mile southwestward along the general line of strike of the Bobs lake deposit, pyrites has also been found, in a small low outcrop barely rising above the soil at the northeast corner of the south half of lot 9, concession III, on the Moyer Veteran claim.

The deposit here occurs in the form of a band of highly pyritous schist. The schist strikes northeastward and the dip is nearly vertical. Drift covers the north side of the pyritous band, but parallel with it on the south side is a band of acidic eruptive rock, and, south of that again, green chloritic schist. A width of 18 feet of interlaminated pyrites and schist is exposed.

An average sample taken across this width yielded:—[2]

	Per cent.
Sulphur	26·10
Iron	42·07
Insoluble residue	5·62
Zinc	0·24
Arsenic	0·009

MCCART TOWNSHIP.

Dan O'Connor's Claim.

In 1916, Mr. Dan O'Connor, of Connaught, Ont., uncovered a showing of pyrites while prospecting for nickel on the south half of lot 7, concession V, of the township of McCart. The occurrence is about 3½ miles west of Nellie Lake siding on the Temiskaming and Northern Ontario railway.

The pyrites was found in some pits and trenches dug through the drift covering the bottom of a shallow valley, or longitudinal depression, in the rocks. These workings were full of water when the property was visited, and consequently not in a condition to afford much information. A large part of the material that had been blasted out was piled up alongside of them, however, and could be examined. This material is a black, cherty-looking, schistose rock through which spherical nodules of pyrites are rather sparingly scattered. In addition to the scattered nodules of pyrites, there are also, intercalated in the black schist, thin, pinching and swelling layers made up partly of nodular pyrites, and partly of quartz. The greatest thickness of pyrites seen in any of these layers was six inches; generally it was under three inches. Considerably less than one-half the volume of the material in the pile would be pyrites.

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[1] H. A. Leverin, analyst.

[2] H. A. Leverin, analyst.

M. B. Baker, who inspected the deposit when it could still be seen in the pits and trenches, says: "Scattered through the ash rock or tuff (black carbonaceous schist) are small, round, ball-like concretions of iron pyrites. They vary in size from that of peas to balls two inches in diameter. In places there is a layer six feet or more in thickness, where these ball-like concretions are so packed together as to be almost touching each other."[1]

A similar occurrence of nodular pyrites associated with quartz in graphitic schist, or slate, is that on the Nicuso Syndicate's pyrites claims, 14 miles southwest of English River station; others, on the Lake of the Woods, have been described by A. C. Lawson[2] and A. L. Parsons.[3]

[1] Twenty-sixth Annual Report, Ontario Bureau of Mines, 1917, p. 272.

[2] Geol. Sur., Can., Annual Report, 1885, p. 58 CC.

[3] Twenty-second Annual Report, Ontario Bureau of Mines, 1913, p. 221.

NON-METALLIFEROUS MINES DIVISION.

I.

LIMESTONES OF ONTARIO AND QUEBEC.

HOWELLS FRÉCHETTE, *Chief of the Division.*

The investigation of the limestones and dolomites of Ontario and Quebec was continued during the summer of 1918.

QUEBEC.

In view of the demand for dolomite in the Province of Quebec, and the scarcity of pure grades of this rock within a short haul of Montreal and other consuming centres, a week was devoted to re-examining certain districts where the best stratified dolomites had been observed during the regular course of this investigation.

The stratified dolomites of this Province belong, almost exclusively, to the Beekmantown formation and, as a rule, are highly siliceous. It was hoped that by a closer examination of certain areas, dolomites suitable for the production of dolomitic lime, or for use in the wood-pulp industry, might be found. The results of this examination, however, were negative.

There are a number of exposures of dolomite, probably of Beekmantown age, about 3 miles east of St. Elizabeth, Joliette county, to the south of the road leading to Berthier. The old quarry on the property of Mme. Ovide Farland was resampled. In a previous report the analyses quoted were obtained from "hand samples," hence it was deemed advisable to secure more representative "average samples." Sample 1 was taken from the upper bed, which is about five feet thick. This stone is light bluish-grey and of very fine texture. Beneath this occurs a layer of almost black spathic material, represented by sample 2. It is irregular in thickness, varying from two feet to almost nothing. Underlying this are heavy beds of a light brownish-grey, fine-grained, porous dolomite, closely resembling that which occurs near Carleton Place, Ontario. Sample 3 was taken from these lower beds which are exposed for a thickness of about six feet. Many exposures in the vicinity were examined, but no pure dolomites were encountered.

Sample Number.	1.	2.	3.
Insoluble siliceous matter	7·94	5·00	12·75
Ferric oxide	0·81	1·13	0·81
Alumina	1·67	0·15	0·99
Calcium carbonate*	56·19	60·86	68·39
Magnesium carbonate†	33·76	30·60	15·75
* Equivalent to lime	31·47	34·08	38·29
† Equivalent to magnesia	16·14	14·62	7·52

Exposures of rock were examined at various points along the river L'Assomption for several miles above Joliette. Such dolomites as were seen were decidedly impure, therefore no samples were taken for analysis.

On a previous visit, in the neighbourhood of Philipsburg, Missisquoi county, samples of dolomites which contained upwards from 7·8 per cent silica and insoluble

matter were secured. A further examination was made, and the two following samples were taken from what appeared to be the purest beds:—

Sample Number.	4.	5.
Insoluble siliceous matter	14·78	4·58
Ferric oxide	0·96	0·32
Alumina	1·44	1·08
Calcium carbonate*	50·12	53·70
Magnesium carbonate†	32·12	38·18
* Equivalent to lime	28·07	30·07
† Equivalent to magnesia	15·35	18·25

These samples were taken along a ridge on lot 4, West Parish, St. Armand township, Missisquoi county, to the southeast of the village of Philipsburg. Sample 4 represents a dark blue, fine-grained dolomite which is exposed over a considerable area. Sample 5 represents a fine-grained, light grey dolomite lying immediately to the east of the foregoing.

Since the first report on this district was published[1] the Canada Carbide Company, Limited, has opened a quarry on the farm of E. H. Morgan, lot 2, range IX, Stanbridge township. The quarry is between 600 and 700 feet long by about 50 feet wide. A spur line from the Grand Trunk railway serves the quarry. Drilling is done by tripod steam drills. From the quarry floor the stone is hoisted by means of a travelling crane and loaded directly into railroad cars. In June about forty men were employed in this quarry.

The stone is a very fine-grained, dark grey, high calcium limestone, of exceptional purity.[2]

Near St. Vincent de Paul, a quarry is being opened, and a very large and well-equipped crusher plant is in course of construction by the Laurin and Leitch Engineering and Construction Co., Ltd. Their works are situated on the south side of the Montreal-Quebec branch of the Canadian Pacific railway, about one mile west of St. Vincent de Paul station. At the time of my visit, work had not progressed sufficiently to enable samples to be taken. The stone is similar to that in N. Brunnet's quarry,[3] which is situated a short distance to the west.

ONTARIO.

The main part of the investigation of the limestones of Ontario was conducted in 1917, but at the close of the field season a number of scattered deposits of more or less importance remained to be visited. These were examined during 1918, and a few points were revisited for the purpose of obtaining additional information.

Lanark County.

Sample 6 is an average taken from extensive exposure of a very coarse-grained, white, crystalline limestone, on lot 29, con. VIII, North Elmsley township, near Otty lake. About ten years ago this stone was used for lime burning, but in recent years no quarrying has been done.

On lot 3, con. IV, Bathurst township, a small pot kiln has been built recently by Robert Tysick. No quarry had been developed in the late summer, but large exposures

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[1] Mines Branch Summary Reports, 1914 and 1915.

[2] For analysis see Mines Branch Summary Report, 1914, page 44, sample 72.

[3] Mines Branch Summary Report, 1914, page 40.

of coarse-grained, crystalline limestone, exist close at hand. Sample 7 was obtained from an opening on the roadside, where stone had been quarried for road work.

Sample Number.	6.	7.
Insoluble siliceous matter	1·50	2·00
Ferric oxide	0·25	0·20
Alumina	0·15	0·20
Calcium carbonate*	89·23	91·72
Magnesium carbonate†	6·80	6·17
* Equivalent to lime	49·96	51·36
† Equivalent to magnesia	3·25	2·94

Hastings County.

Pre-Cambrian rocks underlie the greater part of Hastings county, extending from its northern boundary, southward, to within about 25 miles of the Bay of Quinte, where the Palæozoic limestones are encountered.

Within the Pre-Cambrian area there are many outcrops of crystalline limestone and dolomite. In the majority of cases these rocks are rather impure, containing tremolite, mica, or other silicates, and, sometimes, graphite. Some outcrops show clean material quite suitable for the production of lime, or for other industrial uses. Poor roads and long rail haul to consuming centres adversely influence the development of quarries in the northern section of the county.

Sample 8 represents the white marble in the waste piles at the quarries of the Ontario Marble Quarries, Ltd., on lots 29 and 30, con. X, Dungannon township. This company is in liquidation, and the quarries and mill were idle in July, but were later reopened, under lease, by the Bancroft Marble Quarries, Ltd.

Sample 9 was taken from an old quarry on the southern outskirts of Madoc, from which "black marble" was taken many years ago. The stone is a very dark blue, almost black, very fine-grained Pre-Cambrian limestone, which has undergone very little metamorphism. The beds, which dip vertically, are somewhat banded, and in places carry a small amount of pyrite. The spacing of jointing and bedding planes should permit quarrying blocks of fair size.

The boundary between the Pre-Cambrian and the Palæozoic rocks, which lie to the south, crosses the county in a somewhat irregular course extending from Crow lake eastward, south of Moira lake, and along the twelfth concession of Hungerford township. Numerous, more or less isolated outliers of Palæozoic limestones are seen to the north of this line, notably in the vicinity of Madoc, where they extend northward beyond Eldorado.

Along the northern fringe of the Palæozoic the overburden is light, and local escarpments offer good quarry sites.

Southward, to the shore of the Bay of Quinte, the rocks are exposed in only a few places, owing to the heavy overburden of drift. At Point Anne there are extensive quarries producing crushed limestone and limestone for cement making. At Belleville there is a small quarry from which stone is obtained for city public works, and some stone is taken from the bed of the Moira river for lime burning and other purposes.

In the interior, the only large quarries are situated along the Grand Trunk railway at Crookston. These are described by Parks in his report on building stone.[1] They are at present idle.

Sample 10 was taken from the twenty-foot face of the Gibson quarry, Crookston.

Sample Number.	8.	9.	10.
Insoluble siliceous matter	1·00	2·04	3·15
Ferric oxide	0·81	0·10	0·15
Alumina	0·69	0·10	0·05
Calcium carbonate*	58·20	91·78	88·78
Magnesium carbonate†	39·06	5·51	7·89
* Equivalent to lime	32·59	51·40	49·71
† Equivalent to magnesia	18·67	2·63	3·77

[1] Pages 218 to 220, Report No. 100, Mines Branch.

Ontario County.

Trenton limestone is exposed in low cliffs along the southeast shore of Lake Simcoe, in the township of Thorah. On lot 22, concession I, about six feet of strata are exposed. The beds are thin, the thickest being six inches, and there is much shale in the upper portion. Sample 11 is representative of the lower four feet. The overburden averages about ten feet.

Sample Number.	11.
Insoluble siliceous matter	6·90
Ferric oxide	0·81
Alumina	0·59
Calcium carbonate*	89·50
Magnesium carbonate†	0·80
* Equivalent to lime	50·12
† Equivalent to magnesia	0·38

Between this occurrence and Lake Ontario no exposures of limestone were observed.

Wellington County.

The plant of the Elora White Lime Company, at Elora, was revisited. At the time of my previous visit this plant was undergoing alterations A Shaffer continuous hydrator has been installed, and the battery of kilns increased from four to five; the new kiln having a capacity of from thirteen to fifteen tons per day. A lower cut is being made in the quarry, with the object of securing stone of more uniform quality and freer from calcite inclusions. Number 12 is a sample of the upper loose beds of the old workings in which there are many small cavities lined with calcite crystals. Sample 13 represents the blue bed near the old floor of the quarry. Sample 14 was taken in the new part of the quarry and represents the upper four feet of the new face.

Sample Number.	12.	13.	14.	15.
Insoluble siliceous matter	1·20	1·80	1·10	0·20
Ferric oxide	0·35	0·30	0·30	0·40
Alumina	0·05	0·10	0·70	0·20
Calcium carbonate*	57·10	52·46	54·60	57·10
Magnesium carbonate†	40·45	43·48	43·16	42·02
Alkalies	0·46	n.d.	n.d.	n.d.
Combined water	0·20	n.d.	n.d.	n.d.
*Equivalent to lime	31·99	29·39	30·59	31·97
†Equivalent to magnesia	19·34	20·79	20·64	20·08

Sample 15 is representative of the lower six feet in the quarry of J. L. Maloney,[1] situated on the south side of the Canadian Pacific railway, about one-half mile west of Puslinch station.

Lincoln County.

During 1918 the Imperial Munitions Board obtained stone from the old Gibson quarry,[2] on lot 14, concession VI, Clinton township. Sample 16 is representative of the stone from this quarry.

Sample Number.	16.
Insoluble siliceous matter	0·40
Ferric oxide	0·48
Alumina	0·32
Calcium carbonate*	54·25
Magnesium carbonate†	42·16
*Equivalent to lime	29·38
†Equivalent to magnesia	20·15

[1]See page 36, Mines Branch Summary Report, 1917.

[2] See page 37, Mines Branch Summary Report, 1917

II.

(a) INVESTIGATION OF GRAPHITE AND THE GRAPHITE INDUSTRY.
(b) MICA FOR CONDENSER PLATES.

Hugh S. Spence.

Graphite.

The preparation of the report on graphite—commenced last year—was continued, and many of the mines and mills revisited in order to collect additional data. Several new properties in process of development were visited, also a number of manufacturers of graphite products, both in Canada and the United States. The data collected have been embodied in the writer's report "Graphite" which is to be published by the Mines Branch, and which will shortly go to press.

While little activity was shown in the graphite mining industry during the war period, there are, at the present time, signs of a revival of interest in the possibilities of Canadian graphite. The concentration of flake graphite ores has always been attended with many difficulties, and the mill methods in use have proved so inefficient —both from the point of view of the grade of product made and the cost of production—that few operators have been able to work at a profit. As a result, the record of Canadian graphite has, for the most part, been one long series of failures; notwithstanding the fact that Canadian flake ores compare favourably with any on the American continent, and that far lower grade material has been worked successfully in the United States.

Considerable attention has been devoted in the past two years to the possibilities of oil flotation for concentrating graphite, and the results obtained both on an experimental scale and in actual mill practice have demonstrated that this method offers probably the cheapest and most efficient means of treating graphite ores that has yet been devised. The Callow system of oil flotation has lately been installed in several Canadian mills, and is under consideration by others. In addition, there is a prospect that various abandoned properties, and others hitherto undeveloped, may be opened up; oil flotation being the concentration method to be followed. Many of the flake ore deposits—more particularly the gneissic bands of the Buckingham district, Province of Quebec—offer undoubted possibilities provided a satisfactory method of concentration can be devised.

Mica.

During 1918, the Imperial Ministry of Munitions, being confronted with a shortage of high grade mica suitable for magneto-condenser plates, approached the Canadian Government with a view to ascertaining whether supplies of such mica were obtainable from Canada. In response to this inquiry, the Mines Branch transmitted—through the Imperial Munitions Board—samples of mica representative of the grades procurable from Canadian deposits. The sheets were tested for their dielectric strength by the Imperial authorities, and a report on the results obtained was received by the Mines Branch. The report submitted showed, that certain of the samples—notably those from British Columbia—were eminently suitable for the purpose indicated. An endeavour was made to interest owners of mica mines and claims with a view to obtaining supplies, but before any further action could be taken, a notification was received from the British Government, intimating that owing to lack of bottoms, the project of securing mica supplies from Canada had been abandoned.

III.

SILICA AND MOULDING SAND RESOURCES OF EASTERN CANADA AND SALT IN NOVA SCOTIA.

By L. HEBER COLE.

The investigation of the silica and moulding sand resources of eastern Canada was continued during the field season of 1918. On April 2, at the request of the Imperial Munitions Board for data regarding deposits of silica in Quebec suitable for use in the manufacture of ferro-silicon, I began a special investigation of the silica deposits located in the vicinity of Notre-Dame-des-Anges, and in the Kamouraska district on the south shore of the St. Lawrence, about 70 miles northeast of the city of Quebec. A special report on these two districts was prepared, and handed to the Imperial Munitions Board, and the owners, immediately on my return to Ottawa.

In continuation of the regular investigation, I proceeded on the 10th of June to examine the area lying to the north of the Ottawa river, between Buckingham and Montreal; and then, until the middle of August, spent the time visiting silica and moulding sand deposits in southern Ontario in the district west of Ottawa.

On the 20th of August I went to Fort William to examine the silica occurrences in that district, and also took a short trip up the Wolfe river from Dorion station, 60 miles east of Port Arthur, where I sampled several rocks in that vicinity to determine their suitability for building stones. On my return trip, some quartz and quartzite deposits in the Georgian Bay and Sudbury districts were examined, as well as localities in the vicinity of Cobalt.

On the 2nd of October I proceeded to the Maritime Provinces, and spent three weeks investigating some silica sands and moulding sand deposits in New Brunswick and Nova Scotia.

The field work ended on the 31st of October.

PRELIMINARY REPORT ON THE SILICA DEPOSITS OF EASTERN CANADA.

The silica deposits of Canada have not been exploited to any great extent in the past, and it is only within the last few years that any systematic investigation has been made of any of them with a view to ascertaining their economic value. The attention of the Mines Branch has been concentrated on many of the more promising localities in which silica deposits are to be found, and considerable data have been gathered in the field, with the intention of incorporating the information thus obtained in a bulletin to be entitled "Silica in Canada." The field work so far accomplished in connexion with this investigation has covered the principal localities east of Fort William. Many of the deposits were determined, in the field, as unsuitable for any known commercial use, but wherever there was the slightest possible chance of a deposit being of commercial value, samples were taken for further examination in the Mines Branch laboratories. A number of these proved, on preliminary tests, to be unsuitable, hence no further trials of these will be made. Others give promise of being capable of utilization in one or other of the many forms in which silica is applied in manufacturing and other industries. Altogether, over 100 samples were obtained from representative deposits throughout eastern Canada: consisting of vein quartz, quartzites, sandstones, natural sands, flints, and diatomaceous earth. In order that the results obtained may be promptly available the following preliminary report on the silica deposits of eastern Canada is given:—

Silica.

Silica, sufficiently pure for industrial purposes, occurs in the following forms:—

(*a*) Quartz crystals.
(*b*) Vein quartz.
(*c*) Flint.
(*d*) Quartzite.
(*e*) Sandstone.
(*f*) Sands.
(*g*) Diatomaceous earth.

The utilization of silica in many important industries is varied, and each industry requires the material in a particular form. Thus silica obtained from any of the above forms of occurrence will be best suited to a particular use. The selection of any special form of silica will also depend a great deal on the local conditions, such as availability, transportation facilities, etc.

The more important uses of silica, and the requirements of the several industries, will be dealt with at length in the final report, hence will only be enumerated here. The principal industries employing silica in one form or another are:—

(i) Glass industry.
(ii) Pottery industry.
(iii) Enamelling industry.
(iv) Paint industry.
(v) Smelting industry.
(vi) Manufacture of ferro-silicon.
(vii) Manufacture of carborundum.
(viii) Manufacture of silica brick.
(ix) Manufacture of sodium silicate.
(x) Steel foundries.

Ontario.

The more important occurrences of silica in the Province of Ontario are in the form of sandstones, quartzites, and vein quartz, deposits of which occur in many parts of the province. The main areas will be briefly described.

THE ORISKANY SANDSTONE AREA.

The Oriskany sandstone, the lowest recognized Devonian formation found in Ontario, occurs in isolated and patchy outcrops in a narrow area running from Fort Erie westward to the vicinity of Hagersville. The most important development of this formation is found in the vicinity of Nelles Corners, where it outcrops over several square miles in the townships of North Cayuga and Oneida in Haldimand county. In this area the beds vary in thickness from 1 foot to 20 feet, and rest on dolomite. There is usually very little stripping to be done to expose the beds which are lying horizontally. The rock itself is usually massive and coarse-grained, easily friable, and the colour ranging from a creamy white to yellowish. The friability, and high silica content of this rock, has led to its exploitation as a silica sand; and one company, already, has a plant in operation on lot 49, con. 1, tp. Oneida; and another company is contemplating the erection of a plant nearby.

This area was visited, and a number of samples taken, and material analysed with the following results:—[1]

—	1738	1739	1740	1741	1742	1826	1827
Silica (SiO_2)	87·94	98·78	94·20	79·20	92·59	93·65	89·45
Iron oxide (Fe_2O_3)	·15	·17	·41	·49	·18	·28	·24
Alumina (Al_2O_3)	·54	·09	·39	·01	·08	·22	·06
Lime (CaO)	....	·04	2·80	10·20	....	2·10	4·20
Magnesia (MgO)	....	·10	tr.	1·26	....	·22	·29
Calcium carb. ($CaCO_3$)	5·87	....	....	....	3·59	....	....
Magnesium carb. ($MgCO_3$)	·44	....	....	....	·51	....	....
Loss on ignition	·29	·42	2·00	8·00	·27	1·70	4·20
Totals	95·23	99·60	99·80	99·76	97·22	98·17	98·44

1738. Run of pit (unwashed). Oneida Lime Co., Nelles Corners, Ont., lot 49, con. I, tp. Oneida, Haldimand co.

1739. From outcrop just north of mill (unwashed). Oneida Lime Co., Nelles Corners, Ont.

1740. Crushed and washed sandstone as shipped from mill of Oneida Lime Co., Nelles Corners, Ont.

1741. Material washed out of crushed sandstone and at present allowed to go to waste. Oneida Lime Co., Nelles Corners, Ont.

1742. From north side of quarry to east of mill (unwashed). Oneida Lime Co., Nelles Corners, Ont.

1826. Sandstone (unwashed). North end of S.W. ¼, lot 49, con. I, tp. Oneida, Co. Haldimand, Ont. Consolidated Plate Glass Co.

1827. Sandstone (unwashed). Average sample from the south ½ of lot 4, con. I, tp. of Oneida, and N.W. ⅛ of lot 46, con. 1 N., tp. of North Cayuga, Co. Haldimand, Ont.

These rocks carry a considerable amount of lime as a bonding material, and as can be seen from the above analyses the material from different parts of this area vary considerably in composition. The ease with which the material can be crushed to a sand, and the possibility of removing much of the impurities by washing, serve to increase the silica content, and to make the material suitable for some of the silica using industries.

To the west of Hagersville, Ont., there are sandstone beds exposed on the farm of S. W. Winger, on lot 6, con. XIV, tp. of Walpole, county of Haldimand. These beds are very similar in appearance and structure to the Oriskany sandstone near Nelles Corners; but they are classified by C. R. Stauffer as being the Springvale sandstone of the Onondaga series. A general sample was taken from the face of the ridge in the field just north of Winger's barns, and analysed with the following results:—

—	SiO_2	Fe_2O_3	Al_2O_3	CaO	MgO	Loss on Ignition	Total
1828	98·30	·24	·36	·40	tr.	·20	99·50

To the east of Port Colborne, Ont., on lot 13, Lake Erie front, Bertie township, there is a limestone quarry owned by the Standard Crushed Stone Co. Resting on top of the limestone in this quarry as a 2½-foot bed of siliceous material which is practically a flint. A sample of this material was taken and analysed:—

—	SiO_2	Fe_2O_3	Al_2O_3	CaO	MgO	Loss on Ignition	Total
1829	85·35	·52	·68	5·40	·46	5·30	97·71

[1] The analyses throughout this summary were made by either Mr. F. W. Baridon or E. A. Thompson, of the Mines Branch.

This material is too high in fluxing impurities to be suitable for use in the pottery industry, but is of interest, because this bed occurs at other localities in this area and it is possible that other outcrops where the material is purer may be found.

MILTON AREA.

There is a band of whitish-grey sandstone in the Medina formation in the vicinity of Milton, Ont., running north to Forks of Credit, which has an average thickness of about 12 feet. This material is well exposed in the quarry of D. Robertson and Co., on lot 3, con. VII, township of Nassagaweya. The sandstone is very fine-grained, and rests on shales, and is capped with a considerable thickness of beds of limestone. The material is very irregular in composition, but an average sample was taken for analysis:—

—	SiO_2	Fe_2O_3	Al_2O_3	CaO	MgO	Loss on Ignition	Total
1833.........	91·90	·45	3·65	1·70	·22	·90	98·82

THE PORT ARTHUR AREA.

The district in the vicinity of Port Arthur contains numerous beds of sandstone of Keweenawan age, which are more or less friable, and which range in colour from dark brown to creamy white. Only a few exposures could be visited in the time available, consequently, although the samples taken were from the creamy white variety, it is possible that localities will yield a rock freer from impurities than the samples analysed.

——	SiO_2.	Fe_2O_3.	Al_2O_3.	CaO.	MgO.	Loss on Ignition.	Totals.
1835......................	91·30	·32	4·08	1·90	·72	1·70	100·02
1837......................	92·40	·64	·16	2·40	·61	2·00	98·21
1842......................	81·00	·89	9·31	3·20	1·26	2·40	98·06

1835. Sandstone (unwashed) from the property of Malcolm Watty on the Wolf river, 7 miles north of Dorion station, a point on the C. P. railway, about 50 miles east of Port Arthur, Ont.

1837. Sandstone (unwashed) from Simpson Island quarry, Lake Superior, Ont. Sample obtained from stonecutting yard, Port Arthur, Ont.

1842. Sandstone (unwashed) from quarry near entrance of Black bay, Ont., approximate location being 86° 31′ 05″ longitude and 48° 33′ 10″ latitude.

THE GEORGIAN BAY AREA.

In the territory lying to the north of the Georgian bay, there are extensive deposits of massive quartz and quartzites, which run high in silica, and which are suitable for the manufacture of silica brick, ferro-silicon, or as a flux in the copper-nickel smelters. Already the quartzite from Killarney is being quarried for ferro-silicon manufacture; and the quartzite occurring in the vicinity of Bellevue station on the Algoma Central railway, north of Sault Ste. Marie, is being utilized by the Algoma Steel Corporation, for the manufacture of silica brick. Quartz from the vicinity of the nickel deposits

of the Sudbury region, is being used as flux in the smelters. Samples taken analysed as follows:—

	SiO_2.	Fe_2O_3.	Al_2O_3.	CaO.	MgO.	Loss on Ignition.	Totals.
1839	96·80	·41	1·60	1·00	·36	·30	100·47
1840	98·20	·49	·61	·70	·29	·20	100·49

A sample of calcareous sandstone was also obtained from the Quebec shore of Lake Timiskaming, directly opposite Haileybury, Ont., and analysed:—

	SiO_2.	Fe_2O_3.	Al_2O_3.	CaO.	MgO.	Loss on Ignition.	Total.
1841	41·15	1·05	8·15	15·50	6·01	25·40	97·26

This sample was taken from the rocks in place on the shore, but I have been informed that on weathering, this material becomes white, and that when the water in the lake is low, the sandy beach at this point is composed of a very pure white sand. A marketable material might be obtained by dredging.

THE QUARTZ OF THE ARCHÆAN AXIS.

The area in lower Ontario, in which the ancient crystalline rocks may be found, lies to the eastward of a line from Kingston to the Georgian bay, and west of a line running from a point on the St. Lawrence river west of Brockville, in an irregular manner to the Ottawa river near Arnprior. Through these crystalline rocks many deposits of quartz are found associated with feldspar and a number of these were sampled as well as several quartzite deposits in the same area. The results of the analysis of these samples are as follows:—

Number.	SiO_2.	Fe_2O_3.	Al_2O_3.	CaO.	MgO.	Loss on Ignition.	Totals.
1726	94·35	1·74	2·56	·20	·14	·50	99·49
1810	94·10	45	·70	2·10	·94	·60	98·89
1811	98·70	·32	·33	·40	none.	·20	99·95
1818	99·15	·24	·01	·50	none.	·05	99·95
1819	99·30	·14	·01	·10	trace.	·25	99·80
1820	99·20	·10	·03	·20	none.	·22	99·75
1821	99·25	·08	·02	·05	none.	·20	99 60
1822	98·00	·17	·18	·85	none.	·40	99·60
1824	99·15	·21	·29	·30	trace.	·15	100·10
1825	98·30	·16	·04	·55	none.	·40	99·45
1859	97·72	·32	1·08	none.	·32	·38	99·82

1726. Quartzite from the south ½ of lot 22, con II, tp. of Elizabethtown, Leeds co., Ont.

1810. Quartzite from N.E. ½ of property owned by T. B. Caldwell, Lanark, Ont., situated 1½ miles N.W. of Clyde Forks station, Ont.

1811. Quartzite from the S.W. ½ of property owned by T. B. Caldwell, Lanark, Ont., situated 1½ miles N.W. of Clyde Forks station, Ont.

1818. Quartz from lots 12 and 13, con. VIII, tp. of South Sherbrooke, Lanark co., Ont.

1819. Quartz from property owned by Rinaldo McConnell, lot 6, con. VI, tp. South Sherbrooke, Lanark co., Ont.

1820. Quartz, south ½ lot 9, con. IV, tp. South Sherbrooke, Lanark co., Ont.

1821. Quartz from lot 16, con. XI, tp. of Portland, Frontenac co., Ont.

1822. Quartz from west ½ lot 16, con. X, tp. of Portland, Frontenac co., Ont.

1824. Quartz from the east ½ of lot 5, con. X, tp. of Madoc, Hastings co., Ont.

1825. Quartz from lot 3, con. IV, tp. of Elzevir. From the east bank of the Moira river just north of Actinolite, Ont.

1859. Quartz, lot 22, con. II, tp. of Dungannon near Turiff station, on the C.O. railway, branch of the C. N. railway, about 75 miles north of Trenton, Ont.

The material from any of these deposits is of sufficiently high grade to be utilized for the manufacture of ferro-silicon, or in the pottery industry.

THE POTSDAM SANDSTONE AREAS.

Along the eastern flank of the Archæan Axis, numerous beds of sandstone, of Potsdam-Beekmantown age, are to be found. These beds exhibit great diversity in character, and irregularity in bedding. They are seen as scattered and isolated outcrops from the vicinity of Brockville to Westport and throughout the district north of Kingston; also along the Rideau lakes to Smith's Falls and Perth, and northward to Carleton Place and Almonte. An isolated occurrence of some extent is also to be found in Nepean township. These deposits of sandstone may be tentatively grouped under the following areas:—

KINGSTON AREA.

In the vicinity lying between Kingston and Gananoque, on the St. Lawrence river, and running northwest to Sydenham, there are numerous outcrops of Potsdam sandstone, which were examined; and in a number of cases were found to be fairly white, and uniformly free from iron stains. In several of the outcrops sampled, the white beds were of considerable thickness, and could be readily quarried without having an excessive amount of waste material.

WESTPORT AREA.

In the district around Westport and Newboro, in the townships of North Crosby and South Crosby, there is an extensive exposure of fine-grained sandstone. In many places this sandstone is badly stained with iron oxide, but a number of outcrops were noted and sampled, in which certain beds appeared comparatively free from impurities. This material crushes readily to the natural grain of the sand, which is between the 16 and the 100 mesh.

PERTH—SMITH'S FALLS AREA.

In the neighbourhood of Perth, and between Perth and Smith's Falls, another sandstone area was visited. The iron stained beds noted in the Westport area are also to be found in this area, and the white beds are also present, although they are not so numerous nor so thick.

NEPEAN AREA.

About 9 or 10 miles to the west of Ottawa, a number of quarries have been operated for a considerable time, producing building stone and paving blocks. The waste material from these quarries will average about 95 per cent silica; and in certain beds a white rock can be obtained which crushes readily into sizes suitable for the manufacture of glass.

The samples obtained from these several areas were analysed with the following results:—

Number.	SiO_2.	Fe_2O_3.	Al_2O_3.	CaO.	MgO.	Loss on Ignition.	Totals.
1719..........	97·01	·18	·81	·25	·19	·74	99·18
1720.........	97·40	·39	1·21	·07	·14	·50	99·71
1724..........	97·91	·19	·80	·14	·12	·35	99·51
1725.........	98·47	·17	·25	·40	·09	·19	99·57
				$CaCO_3$.	$MgCO_3$	(H_2O 105°).	
1727.........	95·35	·27	1·11	2·86	·39	·24	100·22
1728.........	97·76	·60	·54	·19	·34	·56	99·99
1731.........	98·57	·15	·38	·34	·21	·49	100·14
1732..........	98·00	·19	·16	·40	none.	1·10	99·85
1735..........	98·50	·28	·34	·28	·11	·42	99·93
1747..........	98·77	·20	·06	tr.	·04	·19	99·26
1753.........	98·80	·12	·18	none.	none.	·40	99·50
1809..........	96·54	·57	2·08	·55	none.	·10	99·84

All these analyses were made on the crude material.

1719. Sandstone, Leeds co., Centre of lot 8, con. VII, tp. of North Crosby, Ontario.

1720. Sandstone, Leeds co., lot 15, con. I, tp. Crosby S., and lot 29, con. V, tp. Bastard, Ont.

1724. Sandstone, Lanark co., south ½ lot 11, con. VIII, tp. of N. Burgess, Ontario.

1725. Sandstone, Lanark co., south ½ of lot 26, con. X, tp. of N. Elmsley, Ontario.

1727. Sandstone, Leeds co., from cliff on shore of St. Lawrence river, on S. ½ lot 36, con. I, tp. Elizabethtown, Ont.

1728. Sandstone, Frontenac co., lot 19, con. X, tp. of Loughborough, Ontario.

1731. Sandstone, Frontenac co., lots 9 and 10, con. VII, tp. of Loughborough, Ontario.

1732. Silica sand, Frontenac co., lot 10, con. VII, tp. of Loughborough, Ontario.

1735. Sandstone, Frontenac co., north ½ lot 16, con. VII, tp. Pittsburgh, Ontario.

1747. Sandstone (salmon colour) north ½ lot 16, con. VII, tp. of Pittsburgh, Ontario.

1753. Sandstone, Nepean Sandstone Quarries, Ltd., South March (Carleton Co.), Ontario.

1809. Sandstone, from property of J. Menzies, Perth, Ont., on the north bank of the Tay canal, 1½ miles east of Perth, Ontario.

Quebec.

Silica is also found in the Province of Quebec in deposits of sandstone, vein quartz and quartzites. The principal deposits are to be found in the following areas:—

POTSDAM SANDSTONE AREA IN SOUTHWESTERN QUEBEC.

The Potsdam sandstone which is so largely developed near the New York border, between Huntingdon and Hemmingford, as well as along the St. Lawrence and Ottawa rivers, is in many places fairly free from iron oxide. The grains of the rock are small, and, in most cases, the material crushes readily. The best exposures with reference to transportation are to be found in the vicinity of Beauharnois, Melocheville, Cascades point, and in the area lying between the St. Lawrence river and Lake of Two Mountains. North of the Ottawa river, a number of outcrops are conveniently situated with reference to the several different railways: notably those at St. Canute and St. Scholastique. Material from these deposits has been used in Montreal and elsewhere for the manufacture of bottle glass; for steel foundry work; and for furnace linings. A number of samples were taken from this area and analysed:—

Number.	SiO_2.	Fe_2O_3.	Al_2O_3.	CaO.	MgO.	Loss on Ignition.	Totals.
1704	87·70	·94	4·42	·25	·24	·13	93·68
1705	96·48	66	·32	·20	·20	20	98·06
1706	89·62	·85	3·73	·26	·15	·69	95·30
1707	93·12	·81	2·57	·22	·20	·35	97·27
1708	96·56	·29	·90	·10	·12	·19	98·16
1710	97·54	·24	·28	·10	·10	·14	98·40
1711	65·90	·49	1·11	11·00	6·12	15·00	99·62
1712	94·80	·40	·10	1·50	·36	·30	97·46
1713	89·70	·65	5·45	2·10	·48	·80	99·18
1714	97·08	·39	·55	·18	·20	·31	98·66
1715	98·25	·16	·17	·70	—	·35	99·63
1750	98·07	·35	·10	03	·27	·32	99·14
1815	99·20	·48	·07	·05	none.	·20	100·00
1816	92·40	1·05	2·95	·50	·29	·70	97·89
1817	94·40	1·05	1·66	1·00	·18	·40	98·69

1704. Sandstone, Huntingdon co., Covey Hill, Que., on the farm of Chas. Brisbin, ½ mile to south of east and west road.

1705. Sandstone, Huntingdon co., on main road between Hemmingford and Vicars, Que., 7 miles west of Hemmingford, Quebec.

1706. Sandstone, Huntingdon co. on east and west road, about one mile west of Maritana, Quebec, on farm of Joseph Foyer.

1707. Sandstone, Huntingdon co. Franklin Centre, Quebec, from bottom of east branch of Ontario creek just north of bridge.

1708. Sandstone, Chateauguay co., on north and south road 4½ miles south of Ormstown, Quebec.

1710. Sandstone, Huntingdon co., on east and west road, 2½ miles west of road from Hemmingford to Barrington, Quebec.

1711. Calcareous sandstone, on road to Mitchell's Corners, 1 mile east of St. Armand station, Quebec.

1712. Silica sand from the farm of G. H. Brooks, lot 6, in the 3rd range of Russelltown, Chateauguay co., Quebec.

1713. Silica sand from the farm of B. Roberts, 2½ miles west of Russelltown, Que., on the road to Stockwell, Que.

1714. Sandstone, Beauharnois co., from quarry of Montreal Sand and Gravel Co., Melocheville, Quebec.

1715. Crushed and washed sand, Montreal Sand and Gravel Co., Melocheville, Que.

1750. Sandstone, Beauharnois, Quebec, from the farm of W. H. Roberts.

1815. Sandstone from the Stinson-Reeb quarry, St. Canute, Quebec.

1816. Crushed sandstone as it comes from the quarry of the Cascades Silica Products Co., Cascades Point, Que.

1817. Washed silica sand as produced by the Cascades Silica Products Co., Cascades Point, Quebec.

A study of these analyses shows that the samples from the southern part of the area run rather high in alumina and iron for commercial use. Number 1711 is a sandstone with well rounded grains embedded in a calcareous bond.

BUCKINGHAM AREA.

In this area are included the outcrops of Potsdam sandstone occurring in the vicinity of East Templeton, the quartz associated with feldspar from the Lievre River district, and the quartzite associated with the kaolin from the property of the Canadian China Clay Co., at St. Remi d'Amherst, Que.

The sandstone occurs as a prominent ridge near the Canadian Pacific railway line running from Ottawa to Montreal. It is iron-stained in many places but is readily crushed and it is possible that it can be washed to a fairly clean and pure product. The quartz of this area is found associated with feldspars in numerous small outcrops on many of the farms of the Lievre district. It is being quarried in the winter by the

farmers and sold to the Electric Reduction Company at Buckingham, Que., where it is utilized as a flux in the preparation of phosphorus.

On the property of the Canadian China Clay Co., St. Remi d'Amherst, Que., the wall rock of the main kaolin deposit consists of a highly shattered quartzite, carrying from 5 to 12 per cent kaolin in the fractures. This material is capable of being washed to a sand which runs over 99 per cent silica.

The following samples were taken from this area and analysed:—

—	SiO_2.	Fe_2O_3.	Al_2O_3.	CaO.	MgO.	Loss on Ignition.	Totals.
1861	98·75	·56	·24	none.	·15	·20	99·90
1812	99·00	·41	·14	·15	none.	·20	99·90
1754	96·30	·46	1·49	·20	trace.	1·10	99·55
1814	99·09	·32	·12	·09	trace.	·20	99·82

1861. Sandstone (unwashed) from the property owned by Mr. Bilsky at East Templeton, Quebec.

1812. Quartz from the stock pile in the yard of the Electric Reduction Co., Buckingham, Quebec. (An average sample of the quartz found in association with feldspar in the Lievre River district.)

1754. Quartzite (unwashed) from the Canadian China Clay Co., St. Remi d'Amherst, Que.

1814. Washed sand from the Canadian China Clay Co., mill at St. Remi d'Amherst, Que.

NOTRE-DAME-DES-ANGES AREA.

Dr. J. Austin Bancroft, in his report to the Quebec Department of Mines in 1915 on the geology of the Notre-Dame-des-Anges district,[1] mentions the occurrence of several areas of Grenville quartzites which might be suitable for use where a high grade silica rock is required.

Two exposures in this locality were examined.

Lots 5 and 6, Con. I, S.W., Tp. of Chavigny, Notre-Dame-des-Anges, Que.

Sample No. 1807 was taken on this property from a massive bed of quartzite which outcrops at the base of the hill on the north side of the Batiscan river. It is covered with a sandy drift at the top of the hill. The rock is massive, very compact, and fairly uniform throughout. Bands of biotite-schist run through the deposit in places, but these are clearly defined and only of limited width. A working face of 25 feet could easily be developed in this deposit. An analysis of this rock gave the following results:—

—	SiO_2.	Fe_2O_3.	Al_2O_3.	CaO.	MgO.	P.	Loss on Ignition.	Total.
1807	97·67	·22	1·93	·13	·13	·005	·21	100·29

Lot 1, Con. V, S.W. Tp. of Montauban, and Lot 1, Con. V, N.E. Tp. of Montauban, Notre-Dame-des-Anges, Que.

Sample No. 1808 was taken from the above property. The quartzites on these lots extend over a larger area, but the ridge does not rise as high as that on the other locality examined. It runs along the south shore of the river just east of the bridge,

[1]See Report on mining operations in the Province of Quebec, 1915, p. 103.

the top of the ridge being possibly 40 feet above low water level of the river. The rock is similar, with the exception of having occasional patches of pure translucent quartz. Its analysis is as follows:—

—	SiO_2.	Fe_2O_3.	Al_2O_3.	CaO.	MgO.	P.	Loss on Ignition.	Total.
1808............	97·46	·18	1·09	·08	·14	·008	·22	100·17

The results of the analyses of the two foregoing samples show that, chemically, this material is suitable for the manufacture of ferro-silicon. The probable difficulty of obtaining it free from the included bands of biotite-schist might increase the expense of preparing a marketable product.

KAMOURASKA DISTRICT.

In the Province of Quebec, between the counties of Levis and Temiscouata, situated along the south shore of the St. Lawrence, there is a well developed series of quartzite hills rising as abrupt dome-like masses above the St. Lawrence lowland, between the St. Lawrence river and Midland upland. According to Mr. J. A. Dresser,[1] these quartzites belong to the Kamouraska formation, which formation consists of quartzites and interbedded conglomerates, and is classified as Middle or Lower (?) Cambrian. These quartzites, which are best developed in the counties of Kamouraska and l'Islet, are found in an area approximately 40 miles in length and 4 miles in width, bordering the shore.

The quartzites are fine, even-grained, and weather to almost a pure white. They appear, in places, to be a partially altered sandstone rather than a pure quartzite. In the southeastern part of the district the quartzites contain nodules of dolomitic limestone, which sometimes are as large as 2 feet diameter, the higher grade material being found in the northeastern part of the area. On this account the examination of the quartzites to determine their utility for manufacturing purposes was confined to the northeastern area in the vicinity of St. Pascal and St. Andre.

From St. Pascal as a centre, a large number of the quartzite ridges were examined, and five different localities were sampled as fairly representative of all the deposits. As the question of transportation with relation to these deposits is of extreme importance, they will be dealt with in the order of their accessibility.

The Pilgrim Islands.

In the St. Lawrence river about 2½ miles off the south shore opposite the village of St. Andre, there is a group of five islands, known as the Pilgrim islands. These are a continuation of the quartzite ridges found on the mainland, and are composed entirely of quartzite. From a casual examination the material appears to be the same on them all; it was therefore decided to confine the detailed examination to the two largest.

The Long Pilgrim Island.

The main island of the group, called the Long Pilgrim, is approximately 2½ miles long, with an average width of 1,200 feet. The major axis of the island runs approximately northeast and southwest. A ridge extending the full length rises 100 to 125 feet above high water level. On the northwest side, the shore is abrupt, and in most places,

[1] See Memoir No. 35, Reconnaissance along the National Transcontinental Railway in Southern Quebec, Geological Survey, Dept. of Mines, by J. A. Dresser, 1912.

the cliff rises directly from the water to 40 or 50 feet above high tide. The southeast slope is more gradual, and in several places there is sufficient fairly level ground at an elevation about 10 feet above high tide on which to erect buildings. Over most of the island, the rock is bare, or covered only with lichens or moss, and the small amount of vegetation present consists of scattered patches of stunted evergreens.

The rock, in most cases, is weathered nearly white, but on breaking, the fresh face appears considerably darker. It is very even in texture and consists of fine rounded grains of quartz in a matrix of siliceous material. It is compact and hard to break with a hammer, but is very brittle, and when broken in the crusher produces considerable fines.

Two large samples, Nos. 1801 and 1802, were taken on this island, each representative of a considerable area. The analyses of these samples are as follows:—

—	SiO_2.	Fe_2O_3.	Al_2O_3.	CaO.	MgO.	P.	Loss on Ignition.	Total.
1801.	98·24	·24	1·52	10	·16	·007	·29	100·55
1802.	97·77	·19	1·27	·10	·17	·008	·29	99·79

The Great Pilgrim Island.

This island is the most northerly of the group. It is approximately 4,200 feet long, by 1,700 feet wide, and contains roughly 133 acres. There are two prominent hills rising to a height of over 200 feet above high water level, one at each end of the island, having a deep depression between them, with very little level ground. There is fairly deep water around the island, which in all other respects is similar to the Long Pilgrim island.

On viewing this island from a distance, one gains the impression that the rock is whiter than that on the Long Pilgrim island, but this is probably due to the fact that there is more bare rock and less vegetation. A fresh fractured surface is considerably darker than the material from any of the other localities visited. Sample 1806 was taken from this island and analysed:—

—	SiO_2.	Fe_2O_3.	Al_2O_3.	CaO.	MgO.	P.	Loss on Ignition.	Total.
1806	98·18	·24	1·34	·14	·25	·010	·45	100·61

With respect to transportation facilities these islands are admirably situated with relation to the principal markets in the Province of Quebec and the Maritime Provinces. From Long Pilgrim island, for example, the crushed rock could be loaded directly into barges at the end of a small wharf, and there would be sufficient water at high tide to enable them to be taken out to the main channel.

ST. PASCAL DISTRICT.

In the vicinity of St. Pascal station, there are a number of quartzite ridges, all of which were examined. The material seems to be very similar throughout. Three samples were taken from different ridges in order to get an idea of the purity of the rock. The ridges are topographically similar to those of Pilgrim islands, having the same general direction, and with steep bluffs on their northwesterly side.

Property of Joseph Lebris, Kamouraska P.O., Que.

Sample No. 1803 was taken from a ridge on the property of Joseph Lebris, 3¾ miles from Pascal station on the Canadian Government railway. The ridge on this property rises about 10 feet above the level of the wagon road on the southeast side, and drops abruptly on the northwest, so that a working face of about 30 feet could be obtained. The ridge examined consists of an area of about 4 acres. The rock is similar in appearance to that found on the Pilgrim islands. Its analysis ran as follows:—

—	SiO_2.	Fe_2O_3.	Al_2O_3.	CaO.	MgO.	P.	Loss on Ignition.	Total.
1803	95·40	·35	1·65	·86	·75	·008	·30	99·31

Property of Arsine Drapeau, Kamouraska P.O., Que.

Sample No. 1804 was taken from a ridge on the property of Arsine Drapeau, 3 miles from the wharf at Kamouraska. This ridge is lightly wooded and rises about 20 feet above the level of the surrounding plain. The general trend of the ridge is parallel to the river. The rock outcrop covers an area of about 6 acres on this property. The following is the result of the analysis:—

—	SiO_2.	Fe_2O_3.	Al_2O_3	CaO.	MgO.	Loss on Ignition.	Total.
1804	96·80	·32	1·13	·60	·43	·35	99·68

Property of Louis Migneault, St. Pascal P.O., Que.

Sample No. 1805 was taken from the property of Louis Migneault, 3 miles southwest from the station of St. Pascal. Here, there is a rugged ridge rising abruptly about 30 feet above the level of the surrounding fields, and running parallel with the Canadian Government railway, from which it is about ½ mile distant. The ridge is lightly wooded, and extends over a number of farms adjacent to the property examined. The average width is 100 yards. The rock in the field appeared similar to that from the other localities examined in this district. The following is its analysis:—

—	SiO_2.	Fe_2O_3.	Al_2O_3.	CaO.	MgO.	Loss on Ignition.	Total.
1805.....	95·42	·42	·68	·80	·62	·30	98·24

The results of the analysis of the 6 samples taken from this district show that the material from the Pilgrim islands is of very high grade chemically, while from the field examination it appears to be sufficiently dense to be suitable for use in the manufacture of ferro-silicon. Samples Nos. 1803, 1804, and 1805, run considerably higher in lime and iron, and lower in silica, and the transportation question for these properties is more serious, due to the lack of cheap water transportation, and the long rail hauls would greatly increase the cost of marketing.

MARITIME PROVINCES.

The silica deposits of the Maritime Provinces consist of natural sand, sandstones, quartzites, vein quartz, and diatomaceous earth. So far as known, there have been no deposits of any of these materials, with the exception of some deposits of diatomaceous earth, worked to any great extent as a source of high grade silica. A number of typical deposits of each class of deposit were visited, and samples taken for analysis.

Prince Edward Island.

About 6 miles east of Souris, P.E.I., a beach sand was obtained which ran well over 95 per cent SiO_2, very low in iron, but with small quantities of probably undecomposed feldspar. The beach from which this sand was taken is, roughly, 1¼ miles long, with a maximum width of three-fourths of a mile, and tapers at both ends. The sand hills are 15 to 20 feet high, so that there is a fairly good quantity of sand available at this deposit. The analysis ran as follows:—

SiO_2.	Al_2O_3.	Fe_2O_3.	TiO_2.	MnO.	CaO.	MgO.	Na_2O.	K_2O.	Loss on Ignition.	Total.
95·72	2·66	0·10	0·20	0·01	tr.	0·10	0·45	0·99	0·24	100·47

It is probable that the high alumina content would cause the sand to be difficult to melt for a glass sand.

New Brunswick.

From the Province of New Brunswick, several silica samples were obtained. These consisted of sandstones and diatomaceous earth.

Sandstone Deposits, at Torryburn, N.B.

An outcrop of sandstone occurs at tide level, on the shore of Kennebecasis bay, to the west of Hastings cove and north of Torryburn station on the Canadian Government railway line from St. John to Moncton. This outcrop rises to a height of about 20 feet, at a distance of 50 yards from the shore. The rock is exposed about 300 feet along the shore, and dips approximately 35° to the southwest. No quarrying has been done on this outcrop.

The rock varies in character in different parts of the exposures, from a badly shattered stone spotted with iron stains, through a medium-grained gritty stone fairly clean and uniform, to a compact, close-grained and very brittle rock, which is practically a quartzite. The outcrop extends about 200 yards back from the shore. Similar rock outcrops about one-fourth to one-third of a mile inland. The sample for testing which was taken from the medium-grained gritty stone at the shore, analysed as follows:—

—	SiO_2.	Fe_2O_3	Al_2O_3.	CaO.	MgO.	Loss on Ignition.	Total
1860........	95·95	·49	2·41	none.	none.	·65	99·50

A sample of creamy white coloured sandstone was submitted for testing by Dr. W. J. Wright of the Geological Survey. This material was obtained from the vicinity of Hillsboro, and it is probable that it may occur in considerable quantities. The rock

is very even-grained and friable, will crush to a satisfactory grain size suitable, when washed, for a glass sand. Its analysis ran as follows:—

	SiO_2.	Fe_2O_3.	Al_2O_3.	CaO.	MgO.	Loss on Ignition.	Total.
	98·15	·32	1·38	tr.	tr.	·40	100·25

Washing will doubtless materially lower the content of alumina.

A number of lake bottoms in this Province contain deposits of diatomaceous earth. Several of these have been worked from time to time, the most important being at Fitzgerald lake, about 8 miles east of St. John. There a bed of about 50 acres of diatomaceous earth has been exposed for exploitation, by draining. The average thickness of the bed is stated to be about 10 feet. The first work on this deposit was done in 1909, experimental treatment being carried on in a small mill, but nothing has been done on this property in recent years. A sample of the material was obtained, and will be analysed shortly.

Nova Scotia.

There are a number of silica deposits in the Province of Nova Scotia which were thought might be suitable for commercial exploitation.

The Dominion Iron and Steel Company have been experimenting for a number of years with a view to producing a silica brick from the quartzites which occur on the east shore of Cape Breton island. This material, a sample of which was obtained from the stock pile of this company at Sydney, is a fine-grained, compact quartzite of uniform texture; and from its analysis, appears to be suitable for the manufacture of silica brick. Its analysis is as follows:—

—	SiO_2.	Fe_2O_3.	Al_2O_3.	CaO.	MgO.	Loss on Ignition.	Total.
	98·60	·41	·29	·90	·21	·10	99·91

Another sample of quartzite (?) was submitted by Dr. A. O. Hayes, of the Geological Survey, from Skye mountain, Whycocomagh district, Inverness county, N.S. This material was obtained from a series of trenches made up the side of the mountain. Its analysis was as follows:—

	SiO_2.	Fe_2O_3.	Al_2O_3.	CaO.	MgO.	Loss on Ignition.	Total.
	85·20	1·58	6·87	2·10	·58	3·60	99·93

On the southwest shore of Nova Scotia there are several beaches of white sand. These sands have been mentioned in a number of reports as being suitable possibly for the manufacture of glass. These beaches were examined in the fall of 1918 and samples obtained. Each one is of considerable extent and has a large tonnage of sand available, but judging from the analyses it is highly improbable that they would be suitable for use in the manufacture of glass owing to the high iron and alumina content.

—	SiO_2.	Fe_2O_3.	Al_2O_3.	CaO.	MgO.	Loss on Ignition.	Total.
1849.........	85·30	2·43	7·77	·60	·56	·67	97·33
1850.........	80·20	·97	14·45	2·50	·32	·30	98·74
1851.........	80·20	·89	14·11	1·80	·25	·60	97·85

1849. Silica sand from Summerville beach, Port Mouton, Nova Scotia.
1850. Silica sand from the southwest beach, Port Mouton, Nova Scotia.
1851. Silica sand from the beach at Barrington bay, Nova Scotia.

CONCLUSIONS REGARDING SILICA DEPOSITS.

Judging from the observations in the field and from the analyses of the samples collected, it seems probable that there are, in eastern Canada, a number of localities where good grades of silica could be profitably produced, and conveniently situated with respect to the consuming centres.

IV.

PRELIMINARY NOTES ON THE MOULDING SAND DEPOSITS OF EASTERN CANADA.

The need, in Canada, for foundry moulding sands of grades suitable for different classes of castings, has increased greatly in the last few years, and has led the Mines Branch to investigate many Canadian sand deposits, to determine their suitability for this class of work. At the present time, a considerable amount of the sand used in Canadian foundries is imported, the supply being drawn mostly from the United States.

In the summer of 1914, investigation of the sand and silica deposits of the Province of Quebec was commenced, the field work being continued during the seasons of 1915 and 1916, and the territory extended to include eastern Ontario. During the seasons of 1917 and 1918 field work was carried on in western and southwestern Ontario as well as a few localities in the Maritime Provinces.

In the course of the field work a number of deposits of sand were encountered, which, from field examination, gave promise of being suitable for moulding sand. Samples of these were taken for laboratory examination and testing.

The tests have not yet been completed, so that only a short description of the localities which were sampled will be given, together with a few notes on the most likely places where sand of suitable grades may be found.

Ontario.

There are a number of localities in the Province of Ontario where moulding sand is found, and several of these deposits are being operated at the present time. Samples were obtained from some of the deposits, and it is proposed to visit a number of other areas this fall.

The principal moulding sand areas at present known are as follows:—

Stamford, Ont.

In the neighbourhood of Stamford, near Niagara Falls, there are several hundred acres underlain by from 1 to 3 feet of fine-grained moulding sand. The area is, in most cases, covered with vegetation, and the cost to clear the surface prior to excavating the sand is considerable. The bulk of the material is being shipped to Buffalo, N.Y. Three samples were obtained from this area.

Stoney Creek, Ont.

At Stoney Creek there is a considerable area of ground with from 2 to 3 feet of moulding sand. By blending the several grades of sand found, a number of mixtures can be obtained, suitable for different classes of castings. A considerable tonnage of sand has been shipped from this deposit each year, to the manufacturing centres of central Ontario. This is probably the largest producing district in Ontario.

Brantford, Ont.

Several miles west of Brantford, Ont., moulding sand has been obtained from a number of farms. This material has been used locally in the Brantford foundries, and has been found suitable for certain classes of work. The deposits are very pockety, and at none of the places visited was any considerable tonnage seen.

Copetown, Ont.

In the vicinity of Copetown there are several deposits from which a considerable tonnage of sand might be obtained. The material is fine in texture, and is convenient to the railway. The sand which is very uniform throughout, will average from 1 to 3 feet in depth.

Crookston, Ont.

About 1 mile to the south of Crookston there is a gravel and sand deposit overlain by about 3 feet of medium-grained argillaceous sand, which might be suitable for a moulding sand for certain work. Test holes drilled revealed the presence of this top sand, extending over 10 or 12 acres. An average sample of this sand was taken for testing.

Brockville Area.

About 2½ miles to the west of Brockville, Ont., between the Grand Trunk Railway line (Montreal to Toronto), and the river road (Brockville to Kingston), there is a considerable deposit of moulding sand of a fine grade suitable for stove plate castings or brass foundry work. This deposit has been tested, and the results published in Mines Branch Bulletin No. 476 published in 1917.

Quebec.

In the Province of Quebec there are several localities where deposits of sand are found, which may possibly be suitable for iron foundries. A few of these deposits were examined, and others will be visited at a later date. The most promising localities are at St. Justine, Joliette, Batiscan, and in the neighbourhood of Three Rivers. At several points on the Gatineau river small pockets of moulding sand occur.

Nova Scotia.

Deposits of moulding sand are known to occur at a number of localities in Nova Scotia. Two areas were visited and sampled.

Belmont, N.S.

Within a radius of 2 miles from Belmont, a station on the Canadian Government railway about 8 miles northwest of Truro, N.S., Mr. Melville Blair is operating a number of pits of moulding sand of different grades.

All of these sands are coarse in texture, and have to be blended to suit different requirements. There is a considerable tonnage to be obtained from this district. A number of samples were taken from this area for testing.

Elmsdale, N.S.

There is a deposit of sand suitable for foundry use, situated on the west bank of the Nine Mile river at the head of the "Red Bridge," 2½ miles from Elmsdale. This deposit is probably an old sand bar of the river, and covers an area of about 25 or 30 acres. Sand has been excavated from a pit to a depth of 12 feet. The top 18 inches appears finer in grain than the rest of the material, so that two grades can be obtained. Mr. Mosher, of Dartmouth, N.S., is the owner. Several samples were obtained.

The following notes which are conclusions from observations in the field should be of assistance in prospecting for moulding sand.

Moulding sands occur in two main types of deposits; but variations of these types may be encountered. These are:—

(*a*) Flood plain deposits, and

(*b*) Re-washed ancient beach sands.

(*a*) Flood plain deposits.

From the nature of a moulding sand—it being essentially a silica sand with each individual grain coated with a more or less plastic bonding material—one would expect to find it occurring where deposits of sand and clay had been intermingled, and worked over by water. As a matter of fact, moulding sands in flood plain deposits are of quite common occurrence. In these beds the sand and clay have been well and intimately mixed by the river currents, and deposited on the higher levels in flood time; the excess of clay being more easily held in suspension, is carried off by the water.

One should look for moulding sands along the upper terraces of the larger rivers of the country such as the St. Lawrence; also along the banks of ancient waterways.

(*b*) Re-washed, ancient beaches.

The second class of deposits which are frequently encountered are of secondary origin. The sand bars and beaches of the ancient seas have been worked over by the waves as lower levels of the lakes and seas are formed. It is in deposits of this class, which are found at a lower level than the old beaches or water margins, that moulding sand may be expected to occur. These deposits are, therefore, to be looked for in the vicinity of the ancient glacial lake margins, such as the Iroquois and Algonquin, which formerly occupied the Great Lakes Basin; and also within the boundaries of the ancient Lake Agassiz in Manitoba. Similar ponded water bodies in glacial times—extending as far as the foot hills of the Rocky Mountains in Alberta—may also have deposits of this character within their margins.

V.

THE WOLFE RIVER DISTRICT, 60 MILES EAST OF PORT ARTHUR, ONT.

Three days were spent on a hurried trip to examine some reported deposits of decorative building stones occurring on the Wolfe river, about 7 miles north of Dorion, a station on the Canadian Pacific railway main line, about 60 miles east of Port Arthur, Ont.

Topography.

The Wolfe river rises in a series of lakes north of the main line of the Canadian Pacific railway, and has cut its course through sand and gravel deposits of a filled-in valley between the prominent diabase sill capped ridges, common to this district. Two waterfalls were seen on this river about a mile apart, the upper one being where the river flows over a series of dark chocolate coloured sandstones, and the lower one over a diabase dike. On the west side of this valley, which, in places, is between two and three miles wide, the slope to the western ridge is very gradual, and a number of square miles of sandy flats are to be seen. The river has a tendency to run parallel and in close proximity to the eastern ridge, which rises abruptly from the river flats, in some cases to a height of 150 feet above the level of the water. In the bed of the river and in the exposed cliffs can be seen a great variety of sandstones and dolomites, and, where the cliff is not broken, these rocks are capped with from 15 to 25 feet of a diabase sill. At one place in the bed of the river the Archæan granite floor is exposed over an area of about three acres.

A number of samples from the different beds examined were obtained. These were cut and polished with a view to ascertaining their suitability for decorative use.

Sample No. 1 was obtained from the bed of the river about 150 yards south of the upper falls. It is a dolomite, and when polished, shows blending of dark green and pink, with dark red blotches surrounding minute inclusions of argentite and native silver. Although the samples collected could hardly be considered as silver ores, further search might reveal workable deposits.

Sample No. 2, from the bed of the river about 50 yards south of sample No. 1, shows character very similar. The green, however, is of a fainter tinge, and the pink colour is more strongly developed. Both of these stones would be suitable for decorative use if they could be obtained in large blocks near transportation.

Sample No. 3 is of a finer texture, and was obtained from a bed 4 feet thick, in the escarpment one-half mile east of the upper falls. It polishes nicely, and has a greyish-pink colour, variegated with dark and light green blotches. It has an overburden, however, of some 25 feet of diabase. Other samples were obtained and polished, and showed up a great variety of colouring, but the beds from which they were obtained were only of small thickness, averaging 1 foot.

The sandstones of this vicinity are very compact and even-grained, and a variety of colours, from pure white to deep chocolate, could be obtained.

Interbedded between dolomites a white, soft, earthly material was observed which had, in places, a thickness of 4 feet. A sample of it was analysed with the following results:—

	SiO_2.	Fe_2O_3.	Al_2O_3.	CaO.	MgO.	Loss on Ignition.	Total.
1836.........	38·32	3·73	9·67	19·68	20·10	8·10	99·60

This is probably an altered volcanic ash, containing some talcose material and kaolin.

These rocks are of interest since they indicate the occurrence of dolomites in this locality. It would not be possible to work them economically, owing to the difficulties of quarrying and the distance from the railway. There is, however, the possibility that beds may be found in similar formations nearer to transportation and in deposits which would lend themselves more readily to commercial exploitation.

VI.

NOTES ON A DISCOVERY OF ROCK SALT AT MALAGASH, NOVA SCOTIA.

A deposit of rock salt of considerable thickness is being opened up in the neighbourhood of Malagash, Cumberland county, N.S. This is the first known discovery of rock salt in the Maritime Provinces, and the first in Canada to be discovered at a depth sufficiently shallow to enable it to be won economically by actual mining.

Discovery and History of the Deposit.

In 1912, Mr. Peter Murray drilled a well for water on his farm on the Malagash road, about 7 miles northeast of Malagash, a station on the Canadian Government railway branch line, operating between Oxford Junction and Pictou. He encountered a strongly saline water and sent a sample of the same to Dr. Frank T. Shutt of the Dominion Experimental Farm at Ottawa. Dr. Shutt reported on this sample as follows:—

> "Our analysis of this water shows it to contain 28·83 per cent total solids, of which 28·32 per cent is common salt. It is in fact a very strong brine.
>
> "There are present very small quantities of sulphate of lime and possibly of allied compounds, but essentially this is a saturated, or practically saturated, solution of common salt".

No action was taken with regard to this discovery until the early months of 1917, when another sample was forwarded to Dr. Shutt, who reported 26·65 per cent common salt content. At this time Dr. Shutt referred the parties interested to Dr. Haanel, Director of the Mines Branch. The Mines Branch immediately obtained another sample for the purpose of having a complete analysis made. It was found to be a saturated brine, its analysis being given in the following table together with four analyses of brine from the Western Ontario district, for comparison.

—	Malagash Brine, N.S.	Western Ontario Brine.			
Sodium (Na)	99·50	96·270	101·728	96·368	100·997
Potassium (K)	0·55	n.d.	n.d.	n.d.	n.d.
Iron (Fe)	0·07	n.d.	n.d.	n.d.	n.d.
Calcium (Ca)	1·37	1·552	1·630	2·496	1·531
Magnesium (Mg)	0·22	·244	·257	·127	·118
Sulphuric acid (SO_4)	3·11	2·631	2·634	1·698	2·803
Chlorine (Cl)	154·70	150·122	158·742	152·294	156·884
	259·52	250 819	265·001	252·983	262·333
Hypothetical combination: Parts per thousand.					
Sodium chloride (NaCl)	252·90	244·860	258·770	245·111	256·891
Potassium chloride (Kcl)	1·04	n.d.	n.d.	n.d.	n.d.
Magnesium chloride ($MgCl_2$)	0·86	·966	1·017	·503	·467
Calcium chloride ($CaCl_2$)	0·22	1·265	1·484	4·964	1·007
Calcium sulphate ($CaSO_4$)	4·42	3·728	3·730	2·405	3·971
Ferric oxide (Fe_2O_3)	0 10	n.d.	n.d.	n.d.	n.d.
	259·54	250·819	265·001	252·983	262·336
Sp. gravity at 15·5°C	1·200	1·197	1·2045	1·178	1·198

As a result of this analysis, it was suggested to the owners that further exploration was desirable in order to ascertain if the parent salt bed could be located. It was decided that I should visit and examine the locality as soon as possible. In June, 1917, when I made my first examination of the property, brine had been encountered in several other drill holes. A study of the local conditions convinced me that there was a good possibility of discovering rock salt in place, hence I strongly advised the owners to continue their prospecting along lines already advised.

In the summer of 1917, A. R. Chambers and George McKay of New Glasgow, N.S., took an interest in the operations, and drilled a series of holes, after which they sank a prospect shaft in June, 1918. In this shaft rock salt was encountered at a depth of 85 feet from the surface. When the locality was again visited by me on October 10, 1918, the shaft had been sunk into the salt formation to a depth of 17½ feet. Since then I have been informed that the shaft has penetrated about 25 or 30 feet in the salt formation and that they are now drifting on the deposit.

The overlying beds appear to be in a nearly horizontal position, and consist of clays, soft shales, gypsiferous muds, etc., while the saline beds appear to dip to the west of south, at an angle of about 25°, and have a strike of S. 70°E.

The saline beds as encountered in the shaft, show, in the upper 12 feet, considerable impurities in the form of mud, but there appear to be banded layers of whiter rock salt below. The indications from a drill hole located on the site of the shaft, are that the salt beds have a thickness at this point of at least 50 feet.

These beds are found associated with beds of gypsum, mapped by Fletcher as of lower Carboniferous age. The gypsum beds are seen exposed on the shore to the north of the shaft. To the south of the shaft there is a small unmapped outcrop of what appears to be a conglomerate. The salt beds are on the south slope of an anticline, and little is so far known as to their lateral extent. To the west, about one mile from the shaft, there is a pronounced fault shown in the shore section, and this may cut off the western extension of the beds. To the east, about the same distance, the occurrence of a marsh, caused by the sea eroding the protecting sandstone barrier to the north, may determine the eastern extension of the deposit. The evidence at hand, however, indicates the presence of a salt formation of considerable extent. On the basis of data obtained from the shaft, from surface indications, and from the drill holes, it is possible that the saline formation, measured at right angles to the dip, may have a thickness of 175 feet.

A general sample of the whiter rock salt was taken for analysis and yielded the following results:—

	Dried at 110°C.
Sodium (Na)	38·45
Potassium (K)	0·20
Iron and aluminium (Fe and Al)	none
Calcium (Ca)	0·25
Magnesium (Mg)	Trace.
Sulphuric acid (SO_4)	0·61
Chlorine (Cl)	59·35
Insoluble in water	1·05
Total	99·91

Conventional combination.

Sodium chloride (NaCl)	97·60
Potassium chloride (KCl)	0·40
Magnesium chloride ($MgCl_2$)	Trace.
Calcium chloride ($CaCl_2$)	none
Calcium sulphate ($CaSO_4$)	0·86
Ferric oxide (Fe_2O_3)	none
Insoluble in water	1·05
Total	99·91

Although the quantities of potash salts present in the two samples examined from this locality are small, it does not of necessity mean that they are absent in commercial quantities in this area. The drilling and prospecting so far carried out indicate, only in the most superficial way, the presence of a large bed at one horizon. The probability of encountering potash salts, interbedded with the sodium chloride at other horizons than the one penetrated by the prospect shaft and drill holes, is quite within the bounds of possibility.

The discovery of this deposit should be of great assistance to engineers in their search for other similar deposits. A careful study of the conditions of the Malagash area may well indicate to those familiar with the Province, other localities where the conditions are similar, and where surface prospecting and drilling might offer a reasonable chance of obtaining results.

Markets.

a. *Domestic.*—

The importance of this discovery to Canada and more especially to the Maritime Provinces can readily be seen. Canada, at the present time, imports over half of her annual consumption of salt, the only production being in southwestern Ontario. The calculated consumption of salt in Canada in 1918 was 296,328 tons[1], valued at $2,535,-465, as compared with a consumption in 1917 of 301,076 tons, valued at $2,041,633. The total sales of Canadian produced salt in 1918 were 131,727 tons, valued at $1,285,-039. Of this, only 893 tons, valued at $16,743, were exported. There is thus an opportunity for a considerable domestic market for salt to replace the imported material. This import of salt in 1918 amounted to 165,494 tons, valued at $1,267,169, and included 51,450 tons of fine salt in bulk, valued at $294,676; 13,941 tons of salt in packages, valued at $156,736; and 100,103 tons imported for the use of fisheries and valued at $815,757. This last item is used largely on the Atlantic and Pacific seaboards. From a study of the trade statistics of the Customs and Trade and Commerce Departments, I think it is safe to say that about 75 per cent of this fisheries salt is utilized on the Atlantic seaboard including the Gulf of St. Lawrence. The average value of this salt at point of shipment for 1918 was approximately $8.15 per ton of 2,000 pounds. The ocean freight rate to bring this salt to Canadian ports of distribution would bring the cost up to at least $10 per ton.

This price will probably be a normal price for salt for fisheries for a number of years to come—the sales price during war times ranging between $15 and $25 per ton at distributing points in Nova Scotia. If, therefore, a deposit of salt can be developed in a centrally located point in Nova Scotia, and a grade of salt produced suitable for the fishing industry, a market of some 75,000 tons valued at $750,000 should be available.

In addition to this, a considerable demand for salt for domestic purposes, in the Maritime Provinces, could be supplied from such a deposit.

b. *Foreign.*—

Among the foreign markets for the salt from the Malagash deposit, the principal ones will be the fishing industry of Newfoundland, which consumes, according to reports, about 50,000 tons per year, and the fishing and metallurgical industries along the Atlantic seaboard of the United States. It will remain to be seen how much of this latter market can be captured by material produced in Canada.

One feature with regard to the Malagash deposit which is well worthy of serious consideration for future action, is the possibility of establishing an industry for the

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[1] Figures given in this section are taken from Preliminary Report on the Mineral Production of Canada, 1918. John McLeish, B.A., Mines Branch, Department of Mines, Ottawa, No. 506.

manufacture of sodium compounds. Situated as this deposit is, with ready access to shipping facilities both by rail and water, and comparatively close to abundant supplies of fuel, it may well be, that an industry using the salt from these beds as the principal raw material could be established, which would turn out products at a price which could compete in foreign markets such as South America and South Africa, with similar material from England and United States.

Although the Canadian market alone, for salt for domestic use or for the chemical industries, would guarantee its success, it will be seen that the favourable location of this deposit to water transportation on the Atlantic seaboard should enable it to develop an export trade with the United States, South Africa, and South America.

FUELS AND FUEL TESTING DIVISION.

I.

WORK AT THE FUEL TESTING STATION, ETC.

B. F. HAANEL, *Chief of the Division.*

During the year 1918 the staff of the Division of Fuels and Fuel Testing was engaged in preparing for publication the results of the large scale tests on the samples of coal received from the Province of Alberta; examining and analysing samples of mine air received from the principal producing coal mines of the Dominion, making chemical analyses and physical examination of oils for the different Departments of the Canadian Government; together with general analyses and determinations of the heating values of coals received from outside sources and of those required in connexion with the work of this Division. The report of the large scale tests on the samples of coal received from the Province of Alberta will include the results of the tests carried out with these samples of coal in the gas producer, in order to ascertain their value as fuels for the production of a power and industrial gas, and their relative value as fuels for the generation of steam.

The machine shop which is under the control of this Division, completed, and had under way, a very large amount of work, in addition to the preparation of the shed formerly used for storing samples of coal, as a laboratory for carrying out large scale tests on the oils recovered from the distillation of oil shale, coals, etc.; and the erecting and fitting of a semi-Deizel oil engine for the purpose of carrying out large scale tests of the oils thus recovered. In addition to the above work, and the construction of new apparatus, repairs to existing machines and apparatus, and the erection of apparatus in the various laboratories of the Mines Branch was performed by the staff of the machine shop. The laboratory for the special investigation of the oils obtained by the distillation of coals, lignites, and oil shales, in retorts especially designed and constructed for this purpose, was begun over a year ago, and is now sufficiently completed to begin such investigation. The research work being carried out on lignites, with a view to determining their proper treatment for briquetting, and the quantity and value of the oils recovered in their carbonization, is still under way; and preparations are being made to investigate the oil shales of New Brunswick, Nova Scotia, and elsewhere, in the same manner.

The staff of the chemical laboratory of the Fuel Testing Division, in addition to the regular routine work, is largely engaged in an investigation concerning the carbonization and briquetting of lignites. This investigation was inaugurated by the Mines Branch, and has proved of great value to the Lignite Utilization Board, which has under way an investigation concerning the commercial briquetting of the western lignites. The progress of the work conducted along this line by the chemical staff of the Fuel Testing Division is set forth in the accompanying report of Mr. Stansfield, Chief Engineering Chemist. Mr. Stansfield's report will show that the laboratory work has been steadily and rapidly increasing, and that new laboratory space will have to be provided in the very near future, in order that the work may be prosecuted efficiently, and without loss of time, and also in order to permit the Division to undertake new and important investigations, which arise from time to time.

Mr. Aleph Anrep, formerly attached to this Division, as peat expert, was, during the latter part of the year, transferred to the Geological Survey Branch of the Department of Mines.

Mr. John Blizard, in addition to his regular duties, was engaged in determining tensile, compression, and hardness tests, in the physical testing laboratory of the Mines Branch, for the Imperial Ministry of Munitions; Department of Naval Service; Department of Militia and Defence; and the Department of Marine and Fisheries. A special investigation of the properties of "Nicu" steel was also carried out by Messrs. T. W. Hardy and John Blizard. This investigation is still under way, and the results will be published in the course of the year.

In order to prosecute investigations of this nature, a new piece of apparatus was installed in this laboratory under the direction of Mr. Hardy, to enable the cooling curves of the steels to be obtained graphically. This apparatus will be used in the further investigation concerning the properties of "Nicu" steel.

Mr. Blizard also prepared a bulletin entitled "The economic use of coal for steam-raising and house heating."

In addition to laying out and directing the work of this Division, the writer has had a large amount of work to perform for the Dominion Power Board, and the Peat Committee of which he is secretary. The writer was appointed a member of the Dominion Power Board, and one of the representatives of the Federal Government on the Peat Committee, which was appointed to investigate and report upon the possibility of manufacturing peat on a commercial basis in Canada. The Peat Committee was appointed jointly by the Government of Ontario and the Government of Canada, and is composed of four members; two appointed by the Ontario Government, and two by the Dominion Government. The secretarial work of the Peat Committee is performed entirely by the writer.

During the latter part of the year the writer was instructed to witness a test of Albert oil shales in the Wallace retort, for which claims were made concerning its alleged superiority over other retorts for the recovery of oils from oil shales, lignites, and other fuels high in volatile matter. This retort, which was of an experimental character, was set up in the laboratory of the St. Claire Gas Company, East St. Louis, Mo. The results of this test are set forth in a detailed report on pp. 75-85.

In addition to the regular duties ascribed to Mr. E. S. Malloch, an engineer of the Fuel Testing Division, the calibration of electro-thermo couples in the Pyrometry Testing Laboratory, are entrusted to him. During this year Mr. Malloch made twenty calibrations of electro-thermo couples: one for the Department of Militia and Defence; one for the Imperial Munitions Board; and eighteen calibrations of instruments used in the laboratory of the Mines Branch.

The summary reports of Messrs. E. Stansfield and A. W. Mantle, show, in detail, the work carried out under their immediate direction.

II.

REPORT ON TEST OF NEW BRUNSWICK OIL SHALES IN THE WALLACE RETORT.

Introductory.

The increasing importance which oil-bearing shales are assuming as a source of oil, in consequence of the rapidly approaching exhaustion of the known oil-bearing fields, has encouraged chemical, oil, and other engineers to devise new methods, or to make alterations in existing processes and methods for the treatment of oil-bearing shales, with a view to increasing both the yield and quality of the oils obtained. But

although many new processes have from time to time been devised; and alterations to existing processes been suggested, the process which has been employed in Scotland for the last fifty years—with modifications resulting from experience gained—is the only one for which positive commercial success can be claimed.

Quite recently, however, Mr. G. W. Wallace, superintendent of the St. Claire Gas Company of East St. Louis, Missouri, who, for some years, devoted his attention to investigations concerning improvements in the methods for the manufacture of town gas and the quality of the resulting coke, took out patents for an invention of a new type of retort for carbonizing coal and retorting oil-bearing shales; and the claims made for the superiority of this retort over existing retorts, and the fact that a company had been formed for the purpose of treating the Colorado oil shales on a large scale by means of his process, led the Hon. Wm. Pugsley to send a sample of oil shale from the Alberta Mines, New Brunswick, for treatment in the Wallace experimental plant at the works of the St. Claire Gas Company. In compliance with the Hon. Wm. Pugsley's request that the tests on this sample of oil shale be witnessed by a member of the staff of the Division of Fuels and Fuel Testing of this Branch, I was instructed to proceed to St. Louis for this purpose.

Wallace Retort.—A description of this invention, and the objectives it is hoped to attain, is contained in the following, which is taken from the patent specification of Canadian Patent No. 189426:—

The main object of my invention is to provide a practicable process for distilling, carbonizing or vapourizing carbonaceous materials that insures the removal and recovery of all of the hydro-carbon gases, vapours, liquids and oils evolved in the distilling operation.

Another object is to provide a distilling, carbonizing or vapourizing process that will produce relatively large amounts of oils and gases that are of great value, due to their improved quality and also high grade metallurgical coke of good density. Other objects and desirable features of my invention will be hereinafter pointed out.

Briefly described, my process consists in subjecting carbonaceous material to heat in a distilling chamber so as to liberate the gases and vapours, removing all of the evolved gases from said chamber in such a manner that the temperature of decomposition, namely, the temperature at which the hydro-carbons are distilled off, is the higest temperature to which the gases are subjected at any period of the distilling operation, collecting the oils and liquids evolved in the distilling operation and removing them from the distilling apparatus immediately before they have had an opportunity to become cracked or overheated, and at the completion of the distilling operation disassembling the distilling apparatus so as to discharge the coked residue and facilitate the cleaning of the orifices through which the gases, vapours and oils escape from the distilling chamber.

My process is applicable to the distillation, carbonization or vapourization of all coals, lignites, woods, oil shales and carbonaceous substances, and while various kinds of apparatus can be used in practising my process, it is essential that an apparatus be used which is equipped with a heated distilling chamber, a perforated take-off duct constructed and arranged inside of the distilling chamber in such a manner that it eliminates the possibility of the evolved gases, vapours and oils contacting with the hot walls of said chamber in escaping therefrom and also insures the recovery and immediate removal from the distilling apparatus of all of the oils and liquids evolved in the distilling operation, and means for enabling the take-off duct and distilling chamber to be disassembled so as to effect the discharge of the coked residue and also facilitate the cleaning of the orifices in the take-off duct through which the evolved gases, vapours, oils and liquids escape from the distilling chamber. I am aware of the fact that processes have heretofore been devised for distilling carbonaceous material which contemplated removing the gases and vapours from the distilling chamber through a perforated take-off duct arranged inside of the distilling chamber, but such processes have not proved successful and can not accomplish the same results as my process, owing to the fact that no provision is made for insuring all of the gases and vapours passing through the coolest zone in the distilling chamber in escaping therefrom, and no provision is made for collecting and immediately removing from the distilling apparatus the oils and liquids evolved in the distilling operation, the prior processes above referred to permitting some or all of the evolved oils and liquids to recondense in the apparatus, to become mixed with the coked residue and to vapourize again and again until it has become cracked into permanent gases and tars of inferior quality. In my improved process all of the gases, vapours and liquids have to travel through the coolest zone of the distilling chamber in escaping therefrom, and the oils and liquids evolved in the distilling operation are not only collected and prevented from mixing with the coked residue, but they are conducted out of the distilling apparatus as soon as they are formed. Furthermore, in my process the perforated take-off duct is withdrawn from the distilling chamber at the completion of the distilling operation and is then cleaned or replaced by another perforated take-off duct, thus eliminating delay and insuring successful results at the next distilling operation, due to the fact that there are no clogged orifices in the take-off duct to retard the escape of the gases, vapours and oils.

The figure of the drawings is a vertical sectional view of an apparatus that can be used in practising my process. The particular design or construction of said apparatus is immaterial, but it is essential that it comprise a retort or distilling chamber, preferably arranged vertically and sealed at its upper and lower ends, a perforated take-off duct arranged inside of said chamber, with its lower end in direct communication with an eduction pipe, thus insuring the collection and recovery at the same point of the gases, vapours, oils and liquids evolved during the distilling operation, and means for enabling said take-off duct and the bottom of the distilling chamber to be moved downwardly or the side wall portion of the distilling chamber to be moved upwardly with relation to the take-off duct and chamber bottom, so as to effect the discharge of the coked residue and also withdraw the take-off duct from the distilling chamber, and thus facilitate the cleaning of the take-off duct at the completion of the distilling operation. In the apparatus herein illustrated A designates a retort or distilling chamber, preferably of cylindrical shape in cross section, that is adapted to contain carbonaceous material, said chamber being heated by any suitable means, such, for example, as products of combustion that are supplied to a combustion chamber B that surrounds the distilling chamber A. A perforated take-off duct C that is arranged at the center of the distilling chamber A has its lower end connected with an eduction pipe D, preferably a pipe in which a suction or partial vacuum is created. In the apparatus herein shown the take-off duct C and the bottom of the distilling chamber A are adapted to be moved downwardly at the completion of the distilling operation, so as to discharge the coked residue from the distilling chamber and also withdraw the take-off duct from the distilling chamber, so as to facilitate the cleaning of the take-off duct. Therefore, the bottom plate 1 of the distilling chamber is removable, the take-off duct C is mounted on said bottom plate, and the lower end of the take-off duct is connected with the eduction pipe D by means of a pipe 2 that can be disconnected from the lower end of the take-off duct and moved out of the path of the bottom plate 1 of the distilling chamber when it is desired to move said bottom plate downwardly. The cylindrical-shaped shell that constitutes the side wall of the distilling chamber A preferably tapers slightly from its lower towards its upper end and its upper end is sealed or cut off from the atmosphere by means of a removable cover 3 that is adapted to be opened, so as to permit the carbonaceous material to be introduced into the distilling chamber. The lower end of said distilling chamber is sealed or cut off from the atmosphere by the bottom plate 1, previously referred to, which is retained in position by bolts or other suitable fastening devices 4. The take-off duct C consists of a perforated member of cylindrical form that extends upwardly through the distilling chamber to a point in proximity to the upper end of said chamber, said take-off duct preferably being of uniform diameter throughout its entire length so that the annular space between the exterior of same and the side wall of the distilling chamber will diminish gradually in cross-sectional area from its lower towards its upper end, thereby causing the heat to penetrate through the material in the distilling chamber substantially uniformly, owing to the fact that the thickness of the body of material in the lower portion of said chamber where the heat is most intense is greater than the thickness of the body of material in the upper portion of said chamber where the temperature is lower. The take-off duct is provided with perforations 5 preferably arranged uniformly throughout the major portion of its length and of a size suitable for the particular carbonaceous material being distilled, said take-off duct being closed at its upper end by a dome-shaped portion 6 which is imperforate. It is not essential that the upper portion of the take-off duct be imperforate, but it is essential that sufficient carbonaceous material be in the distilling chamber to cover the orifices in the take-off duct.

When heat is applied to the walls of the heating chamber A all of the gases and vapours evolved from the carbonaceous material in said chamber are forced or drawn into the duct C through the perforations 5 therein, said gases and vapours travelling downwardly through the take-off duct to the eduction pipe D, and thence through said eduction pipe to a storage tank or to the place where they are to be consumed. As the take-off duct is arranged at the center of the distilling chamber at the coolest part of the body of carbonaceous material in said chamber, and as said take-off duct affords the only outlet for the gases and vapours, it will be evident that the gases and vapours, in escaping from the distilling chamber, pass through the coolest part of the material being distilled. In fact, from the moment the gases and vapours are evolved they follow a path, in escaping from the distilling chamber A, that will cause a reduction in the temperature of said gases and vapours below the initial temperature of formation, thus preventing any further breaking down of the hydro-carbon molecules. The above is also true of the oils and other liquids evolved in the distilling operation, and in view of the fact that the oils and liquids which enter the take-off duct C are collected in said duct and immediately removed from the apparatus through the suction pipe D, there is no possibility of the oils condensing, revapouring or becoming cracked or mixed with the coked material surrounding the take-off duct, as would occur if the oils were permitted to collect and remain in the perforated take-off duct.

By removing the gases, vapours and oils from the distilling chamber in the manner above described and preventing the oils from mixing with the coked residue, a larger yield of hydro-carbon oils is obtained than is possible with any of the distilling processes heretofore in use, and as none of the oil vapours are allowed to come in contact with the heated walls of the distilling chamber or in contact with the hot coked material in proximity to said walls, it is evident that the oil which is obtained will be free from all of the less valuable unsaturated hydro-carbons that are produced at high temperature, the oil having no free carbon or lamp black. It is also evident that the oil, by reason of the fact that it is not subjected to excessive and prolonged heat treatment, will contain all of the valuable hydro-carbon oils that are produced.

At the completion of the distilling operation the fastening devices 7 that detachably connect the pipe 2 to the lower end of the take-off duct C are removed and said pipe 2 is then moved laterally into an inoperative position, or, in other words, out of vertical alignment with the

bottom plate 1 of the distilling chamber. Thereafter, said bottom plate 1 is moved downwardly so as to effect the discharge of the coked residue from the distilling chamber and also withdraw the take-off duct C from the distilling chamber. The orifices 5 in the take-off duct are then cleaned or a fresh take-off duct is arranged in operative position in the chamber A to be used in the next distilling operation. This feature of removing the take-off duct from the distilling chamber at the completion of the distilling operation is an essential characteristic of my process and is one of the things that makes my process practicable from a commercial standpoint, for I know, from practical experience, that in the operation of distilling coal the coal first softens and then becomes a pasty mass which spreads out in every direction, especially in the direction in which the gases and vapours flow in escaping from the distilling chamber, thereby causing the orifices in the take-off duct to become clogged or choked up each time a charge of carbonaceous material is distilled in the apparatus. By bodily removing the take-off duct from the distilling chamber in the manner above described I am able to clean same quickly and thoroughly or replace the take-off duct with a fresh take-off duct. Consequently, I overcome the necessity of taking the apparatus out of service for a considerable period and I also insure ample exit openings for the escape of the gases, vapours and oils from the distilling chamber during the distilling operation.

By removing the gases, vapours, oils and liquids from the distilling chamber in such a manner that all of the gases, vapours and oils have to flow from the hottest point to the coldest point in the distilling chamber, in escaping therefrom, I secure all of the advantages of low temperature distillation. In fact, I have the ideal conditions of low temperature distillation increased to their fullest possibility, in that none of the escaping gases, vapours and oils touch the heated walls of the distilling chamber, and further, that all of said gases, vapours and oils start to cool immediately after they have been formed. In my process the temperature of formation is the hottest or highest temperature to which any porion of the gases, vapours and oils are subjected, and thereafter, during the continuance of the process, the gases, vapours and oils gradually cool off, all of the above advantages being obtained without the necessity of carrying the temperature of the distilling chamber so low that the coke produced is of little or no value, on account of its lack of structure. In fact, with my process it is possible to carry a temperature high enough to produce a metallurgical coke and still have all of the advantages of low temperature distillation from the oil and gas yield standpoint. It is immaterial whether the gases, vapours and oils are forced out of the distilling chamber by the pressure created in said chamber or are drawn out of said chamber by a vacuum. I prefer, however, to remove the gases, vapours and oils from the distilling chamber by a vacuum that is varied according to the carbonaceous material used and regulated by the temperature used and by the oil and gas being produced. With the process above described it is possible to obtain from coal oils that are brown in colour, greasy, not at all sticky and having none of the sticky, black, viscous characteristics of tar. Furthermore, when coal is distilled by the above process the oils that are obtained are high in tar acids and are free from napthalene, free carbon and other objectionable substances.

What I claim and desire to secure by Letters Patent of the Dominion of Canada is—

1. A process for distilling, carbonizing, or vapourizing solid carbonaceous materials, characterized by applying heat externally to a chamber in which solid carbonaceous material is arranged and protecting said material from the action of air, liquids or gases other than the gases and liquids evolved in the distilling operation, withdrawing under reduced pressure all of the evolved gases, vapours and liquids and causing them to travel through the coolest portion of the material in said chamber in escaping from the chamber, and collecting and immediately removing all of the oils and liquids evolved in the distilling operation.

2. A process for distilling, carbonizing, or vapourizing solid carbonaceous materials, characterized by arranging solid carbonaceous material in a chamber, heating the walls of said chamber and withdrawing under reduced pressure all of the evolved gases, vapours and liquids into a discharge passageway at the centre of the mass of material in said chamber, and removing from said centre passageway all of the evolved gases, vapours and liquids that enter same, the material in said chamber being protected, during the distilling operation, from the action of gases or oils other than those evolved from said material.

3. A process for distilling, carbonizing or vapourizing solid carbonaceous material, characterized by arranging solid carbonaceous material in a chamber that is sealed or cut off from the atmosphere and which is provided at its centre with a vertically-disposed perforated take-off duct that constitutes the sole outlet from said chamber during the distilling operation, applying heat externally to the wall of said chamber, thereby heating the material therein and withdrawing under reduced pressure all of the evolved gases, vapours and liquids into said take-off duct, and causing all of the gases, vapours and liquids that enter said take-off duct to flow downwardly through same and immediately escape from said take-off duct.

The general arrangement of the Wallace experimental plant and a sectional view of the retort are shown in figures 1 and 2. The retort shown in figure 1 is essentially the same as that described in the patent specifications, instead, however, of discharging the carbonized or spent substance by withdrawing the take-off duct through the bottom of the retort, the take-off duct is withdrawn from the top by removing cap plate (F). The capacity of this retort is 90 pounds of coal.

Shale Tested.—The shale sent to East St. Louis, by the Hon. Wm. Pugsley, was taken from an opening on seam No. 1, Frederick Brook, Albert Mines, and represented a fair average of the seam. The seam from which it was taken is 4½ feet wide. This information was received from the Hon. Wm. Pugsley.

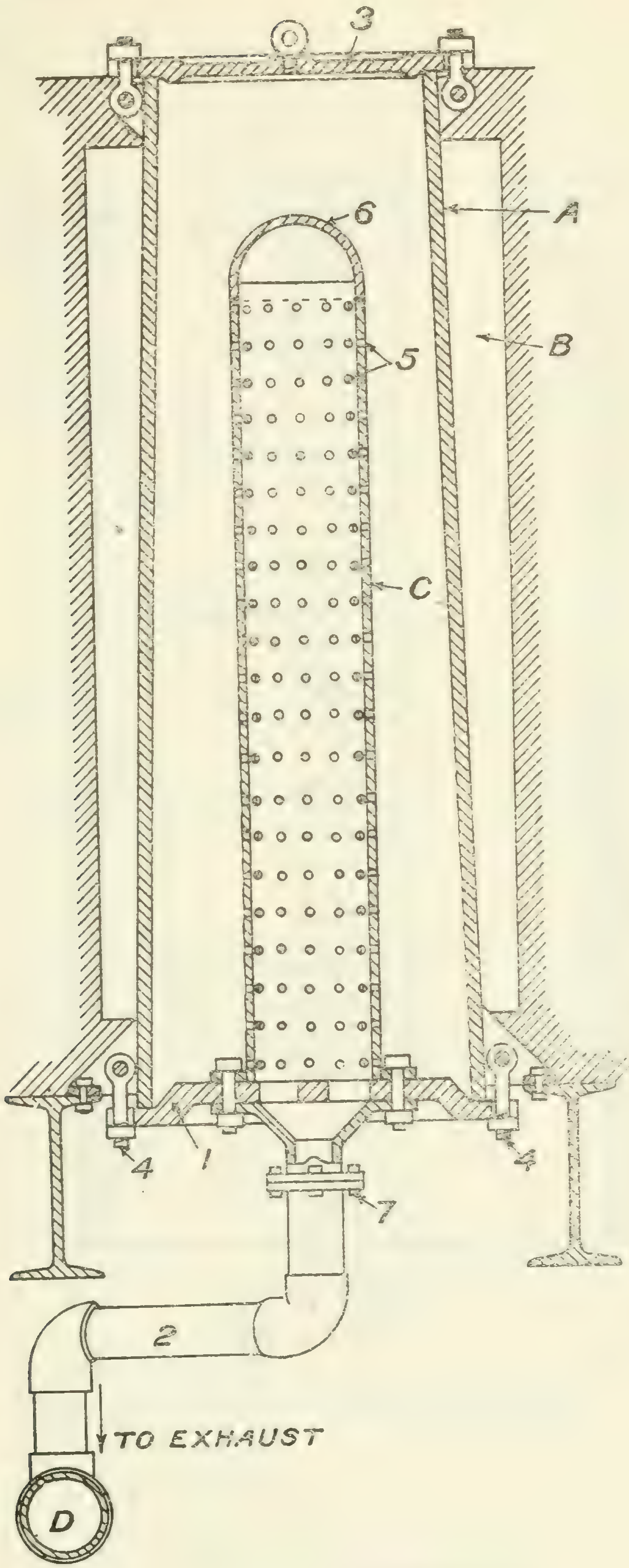


Fig. 1.—Detail of Wallace retort.

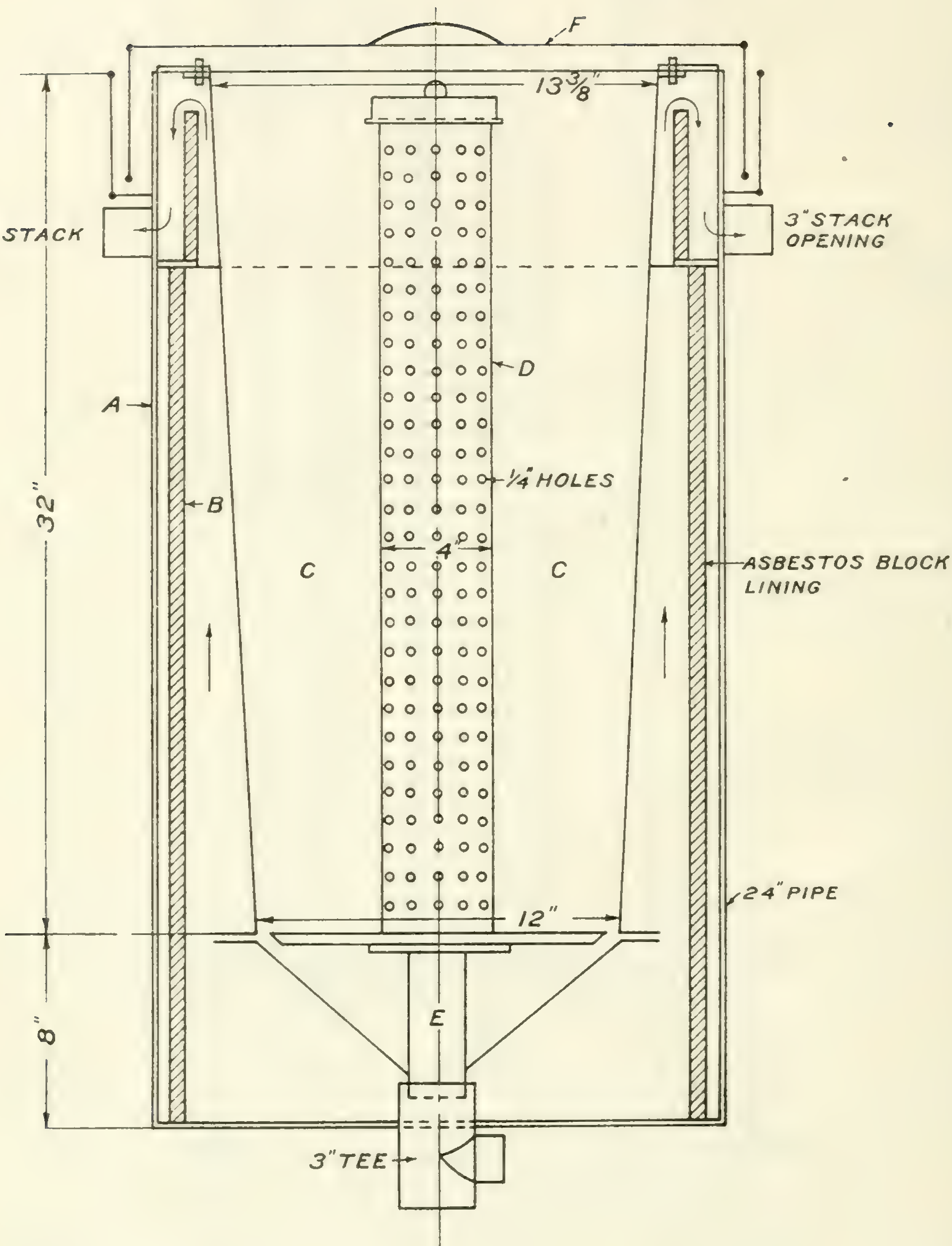


Fig. 2.—Detail of Wallace retort capacity 90 lb. coal.

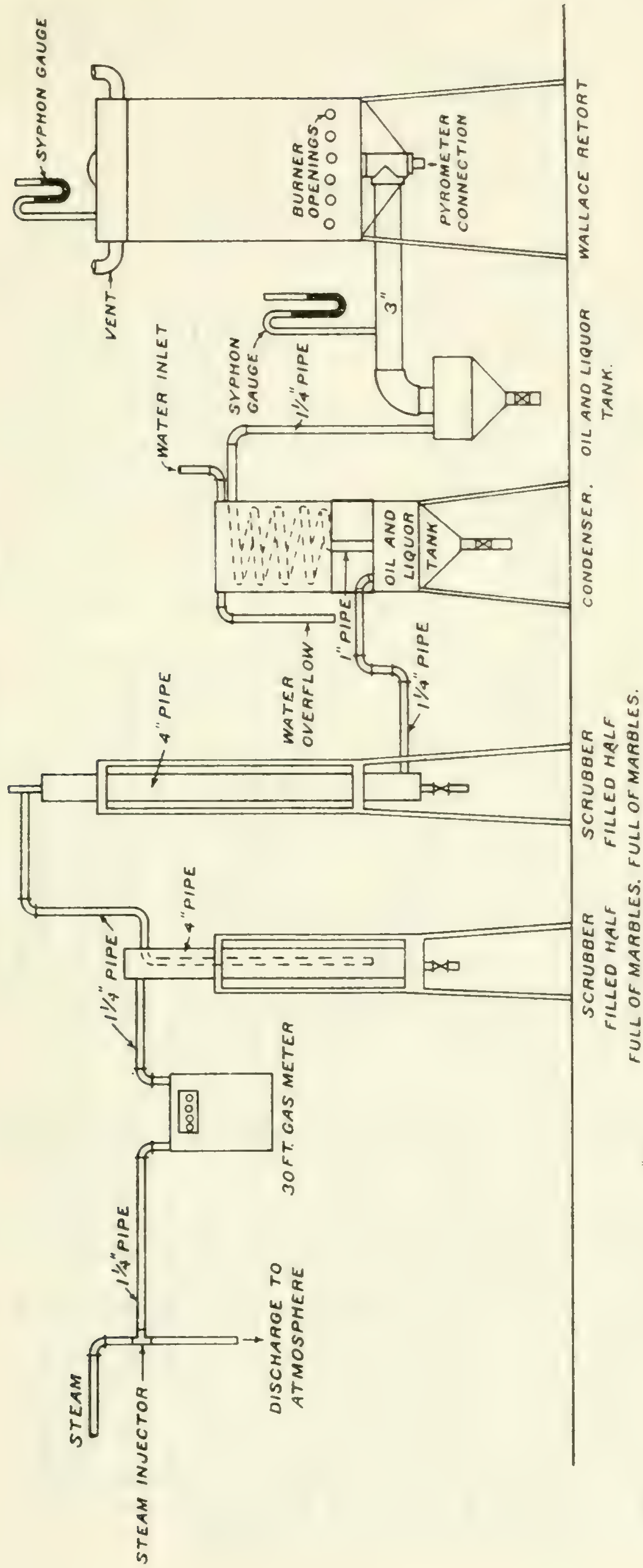


Fig. 3.—General arrangement of the Wallace experimental plant.

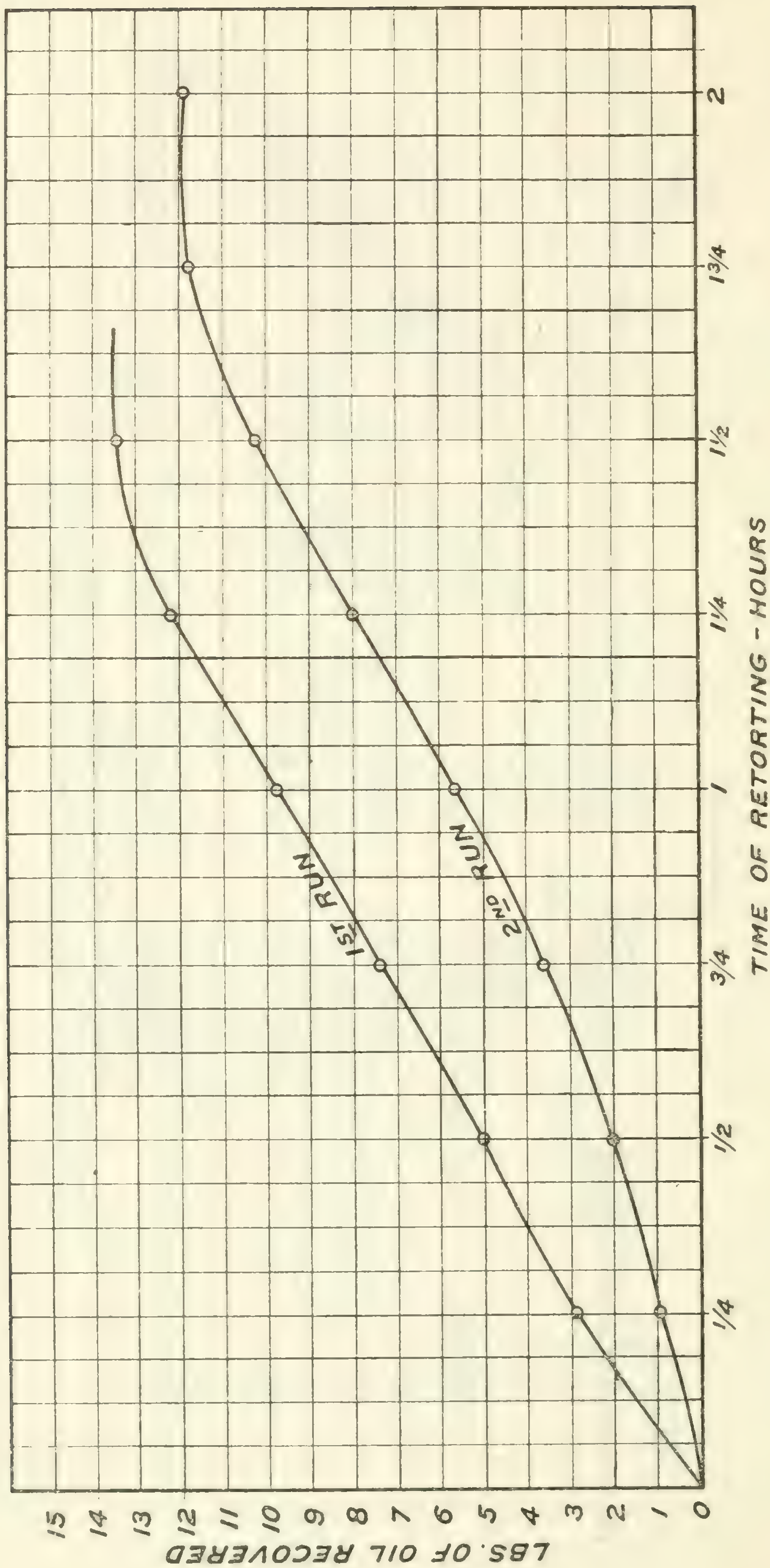


Fig. 4.—Chart showing oil distilled at 15-minute intervals

The shale was sent in two sealed sacks, and weighed 161½ pounds.

On the writer's arrival at the laboratory where the test was conducted, the sacks were opened, and the pieces of oil shale crushed to about ½-inch size. A general sample of the crushed shale was taken, and sent to Ottawa for the purpose of making a check test in the laboratories of the Fuel Testing Station.

Result of tests.—The total quantity of shale received at the laboratory of the St. Claire Gas Company was 161·5 pounds, and this was divided into two lots 81·5 and 80 pounds each, which were retorted in two separate tests.

Test No. 1.—Before charging, the retort proper was brought to a cherry-red heat, while the temperature of the combustion chamber was 1480° F. Pyrometers were placed in the combustion chamber, in the retort, between outside walls and off-take duct, and in the bottom of the eduction pipe, and the temperatures throughout this run were recorded at these points.

The test was commenced at 9.20 a.m., and concluded at 10.50 a.m. The following table gives the temperatures recorded at 15 minute intervals, and the quantity of oil and gas recovered at these periods:—

Time.	Temp. Combustion Chamber.	Temp. Retort.	Temp. Eduction Pipe.	Cu. Ft. Gas.	Weight of Oil.	
					Lb.	Oz.
9.20 a.m....	1480° F	....	1100° F	.....	.....	.....
9.35 "	1480 "	240 °F	600 "	30	2	15
9.50 "	1490 "	280 "	500 "	50	2	1
10.05 "	1510 "	510 "	540 "	20	2	6
10.20 "	1520 "	620 "	650 "	25	2	7
10.35 "	1540 "	720 "	700 "	25	2	6
10.50 "	1530 "	820 "	810 "	25	1	3

Summary of results.		Per ton of shale.
Shale charged....	81 lbs. 5 oz.	
Oil recovered......	13 " 6 "	43 U. S. gals.
Gas	175 cu. ft.	4,290 cu. ft.
Spent shale......	52 lbs. 15 oz.	1,297 lbs.

The oil recovered, viz., 13 pounds 6 ounces, contained a small quantity of water which was not determined. The calorific value of the gas produced also was not determined.

Test No. 2.—The temperature of the combustion chamber and retort before the charge was inserted was considerably lower than that which obtained for the first test, consequently, the yield of oil at the end of the first 15 minutes period was much less than in the former test.

Only two temperatures were recorded during this run—the temperature of the combustion chamber, and of the off-take duct. The quantity of gas produced was not recorded.

Quantity of oil shale retorted—80 pounds.

Time.	Temp. Combustion Chamber.	Temp. Off-take Duct.	Quantity of Oil.	
			Lbs.	Oz.
11.25 a.m.	1360° F.	740° F	—	—
11.40 "	1400 "	330 "	—	14
11.58 "	1410 "	400 "	1	3
12.10 p.m.	1420 "	510 "	1	8
12.25 "	1430 "	630 "	2	1
12.40 "	1440 "	710 "	2	6
12.55 "	1450 "	800 "	2	3
1.10 "	1460 "	900 "	1	8
			0	8

Summary of results.		Per ton of shale.
Shale charged	80 lbs.	
Oil recovered	11 " 14 oz.	39·6 U.S. gals.

An air leak developed during this run, which was found to be due to a defective gasket between the top cover plate and the top of retort, hence the lower yield of oil is probably due to the air admitted into the charge of shale oxidizing some of the oil.

The yields of oil for 15 minute intervals during the two runs is shown on the accompanying curves. The oil recovered from the entire sample of shale was shipped to the Hon. Wm. Pugsley, at his request, hence no analysis or tests were made to determine its character.

Analysis and results of test of sample of Oil Shale sent to Fuel Testing Station.

In order to check the results obtained with the Wallace retort, a general sample representing the entire quality of shale retorted, and a sample of the spent shale, were sent to the laboratories of the Fuel Testing Station in order to permit the necessary determinations to be made.

In regard to the method of retorting employed in the above laboratories, it must be borne in mind that no provision is made for charging the laboratory retort hot: therefore no attempt was made to determine the quantities of oil evolved at 15 minute intervals. In fact, such determinations are unnecessary, unless the quality of the oil is changing during the period of retorting on account of reactions effected by contact of the oil evolved with hot carbon, or by cracking due to contact with hot surfaces or exposure to high temperatures. Conditions of this nature did not obtain either in the Wallace retort or the retort employed in the Fuel Testing Laboratories. The latter retort was kept under perfect control as regards temperature.

Analysis—	As Received.	Dried at 105°C.
Moisture	0·9	—
Ash	61·1	61·6
Volatile matter	33·9	34·2
Nitrogen	0·9	0·9

Distillations.	No. 1. Without Steam. 740°C.	No. 2. With Steam. 550°C.
Yield of crude oil, per 2,000 pounds charged . . Imperial gal.	35	39
United States "	42	47
Yield of completely dried oil per 2,000 pounds charged . . Imperial "	31·4	31·4
United States "	37·6	37·3
Specific gravity, completely dried oil	0·87	0·89
Yield of gas per 200 pounds charged . . cu. ft.	3,700	3,540
Composition of gas—		
Carbon dioxide	25·1	31·0
Illuminants	2·5	2·6
Oxygen	0·2	0·5
Carbon monoxide	19·8	5·2
Methane	24·6	23·2
Hydrogen	21·7	32·6
Nitrogen	6·1	5·1

	No. 1. Without Steam. 740°C.	No. 2. With Steam. 550°C.
Calorific value, B.Th.U. per cubic foot gross	419	395
" " " net	380	351
Yield of ammonium sulphate per 2,000 pounds charged ..lb.	16	19
Nitrogen in residue ..per cent.	0·5	0·7
Distribution of nitrogen from charge—		
In ammonia ..per cent.	21	24
In residue "	42	58
In gas and unaccounted for "	37	18

Sample of spent shale from Wallace retort.

Nitrogen "	0·5

The yield of oil obtained with the Wallace retort checks remarkably well with that obtained with the retort employed in the laboratories of the Fuel Testing Station, especially since the maximum quantity of oil is extracted by means of the method employed in these laboratories.

The quantity of gas obtained is also in close agreement with that obtained in the Fuel Testing Laboratory.

If all of the nitrogen contained in the raw shale, with the exception of that contained in the residue after retorting, is recovered as ammonia, then we may assume that the recovery of nitrogen as ammonia in the two cases, is the same, since the nitrogen content of the spent shale in both cases is 0·5 per cent.

The Wallace retort is intermittent in operation, but this does not appear to be a disadvantage, since the charging and recharging can be easily accomplished with very little loss of time. Moreover, the withdrawal of the spent contents with the take-off duct insures better operation of the retort when it is freshly charged, since this permits both the take-off duct—which is perforated with many small holes—and the walls of the retort itself, to be thoroughly cleaned.

The retort employed at East St. Louis for distilling the New Brunswick shales was designed for investigating the coking properties of low grade coals, and since the coked mass of coal adheres to the take-off duct, the contents could be more advantageously removed by withdrawing the take-off duct through the top.

The New Brunswick shales exhibited a marked tendency to agglomerate and adhere strongly to the take-off duct, so that no trouble was experienced in withdrawing the spent shale in the manner described. Certain shales, however, disintegrate into fine particles when submitted to heat, and consequently, the spent charge cannot be withdrawn conveniently through the top. For this reason, provision is made for discharging the retorts through the bottom in the plant which is now in course of erection in Utah.

It is unfortunate that the retort was not so arranged that the quantity of heat required for retorting could be measured, since the commercial value of such a process largely depends on the heat which has to be supplied for retorting. With regard to this, however, the writer was informed that the expenditure of heat for retorting was low.

III.

CHEMICAL LABORATORIES OF THE FUEL TESTING STATION.

EDGAR STANSFIELD, *Chief Engineering Chemist.*

The regular personnel of the Chemical Laboratories of the Fuel Testing Station remained unchanged during the year. R. E. Gilmore was engaged throughout the year upon an investigation of lignite; J. H. H. Nicolls was in charge of work on coal and other solid fuels; T. W. Hardy in charge of gas analyses; R. C. Cantelo in charge of oil analyses; and J. Moran in charge of mine air analyses. In addition to the above, J. S. G. Shotwell acted as student assistant during June, July, and August.

The laboratory accommodation also remained unchanged during the year, although, as has already been stated, the accomodation is insufficient and unsatisfactory. It is extremely desirable that an entirely new laboratory building should be constructed to replace the scattered and temporary quarters at present available, and to permit and facilitate the development of the work.

The equipment has been increased by the purchase of the following special apparatus: 1 Edwards gas density balance; 1 Westphal specific gravity balance; 1 Crowell pressure and vacuum pump, with motor; 1 30-light, Monel metal, test meter; 2 constant pressure gas regulators; 1 Burrell's mine air analysis apparatus; 1 Sharples super-centrifuge; and 2 sets of modified Jones' riffles.

The total number of samples submitted for analysis during the year from outside sources was much in excess of that for 1917; the increase being entirely due to a more than 100 per cent increase in mine air samples. No count is made of the samples arising from the special investigations carried out in the laboratory. The reduction in the number of routine samples received, other than mine air samples, has allowed exceptionally good progress to be made with several important pieces of work, notably in connexion with the lignite investigation described elsewhere.

The samples received include: 788 mine air; 119 coal; 97 oil, gasoline, and grease; 6 oil shale, gravel, and sand; 3 natural gas; 2 ash; and 10 miscellaneous samples. Of the above samples 788 were analysed in connexion with the testing of mine air; 78 for the Geological Survey; 46 for the Department of Militia and Defence; 34 for the Fuel Controller; 33 for the Lignite Utilization Board; 7 for other Divisions of the Mines Branch; 4 for the Grand Trunk Pacific Railway; 4 for the Department of Public Works; 2 for the Department of the Interior; 2 for the War Purchasing Commission; 2 for the Department of Soldiers' Civil Re-establishment; 1 for the Department of Marine and Fisheries; 1 for the Imperial Ministry of Munitions; and 23 for private individuals. Seven hundred and forty-seven of the mine air samples came from British Columbia, 38 from Alberta, 2 from Nova Scotia and 1 from Ontario.

Marked progress was made during the year with the investigation on lignite previously referred to. The carbonization tests were carried forward to the point where sufficient data had been collected to make it possible to design a large scale retort. Briquetting tests were commenced and were in full operation at the end of the year; relative tests were made on a number of binders and on other possible variants in the preparation and treatment of briquettes. A short account of the work then completed was published in a paper by E. Stansfield and R. E. Gilmore, read before the Royal Society of Canada, May 1918, (Trans. Royal Soc. of Canada, series III 1918, Vol. XII, P. 121). A short summary, with tables and curves, of the completed tests on carbonization is given in the following appendix.

Another special piece of work was commenced towards the end of the year by R. C. Cantelo. He carried out a large number of chemical and physical tests on samples

of wash oils, before and after their use for the extraction of gasolene, in connexion with an investigation on the gasolene content of Canadian natural gases by D. B. Dowling of the Geological Survey.

The regular work of the laboratory was on the whole kept well up to date throughout the year. A marked exception was in the examination of mine air samples, as at the end of the year this work was much in arrears. Arrangements were made to transfer the testing of the mine air samples taken in British Columbia and Alberta from Ottawa to Vancouver, in order to save delay in transit. A duplicate equipment was prepared for Vancouver, but the change had to be postponed.

From October 1, the services of the writer were loaned by the Department of Mines to the Lignite Utilization Board of Canada; a body appointed primarily to establish a commercial industry in Saskatchewan; and in this connexion he made an extended tour through Canada and the United States, visiting carbonizing and briquetting plants, etc.

Five Mines Branch Bulletins Nos. 479-483 "Analyses of Canadian Fuels" a compilation of Canadian fuel analyses by E. Stansfield and J. H. H. Nicolls, were published early in the year: Part I, The Maritime Provinces; Part II, Quebec and Ontario; Part III, Manitoba and Saskatchewan; Part IV, Alberta and the Northwest Territories; Part V, British Columbia and Yukon Territories. Part IV includes an appendix on distillation tests of crude petroleum and its products. The writer read a paper on the Low Temperature Carbonization of Fuels before a general professional meeting of the Canadian Society of Civil Engineers in Toronto, and a paper on Fuels from the Chemists' Viewpoint before the Ottawa Branch of the Society of Chemical Industry.

IV.

LIGNITE CARBONIZATION.

Edgard Stansfield and Ross E. Gilmore assisted by J. H. H. Nicolls, T. W. Hardy, R. C. Cantelo, and others.

INTRODUCTION.

Although Canada has enormous deposits of coal, many parts of the Dominion are inadequately supplied with fuel. The industrial development of the country has apparently taken place largely without regard to its coal resources, or, more strictly, has developed with regard only to a coal supply from the United States. Moreover, certain large deposits of coal in the prairie provinces are difficult to utilize, being low grade fuel. An investigation, having for its objective the efficient use of such low grade fuels, is now being carried on by the Mines Branch of the Department of Mines. This report deals with a part of that investigation.

The problem of coal supply in southern Saskatchewan and Manitoba is serious, and yet possible of prompt solution on account of the Souris lignite coal field in that district. Because of the above, and because lignite from this district is particularly low grade, Souris coal was chosen for first consideration.

An analysis of a carload sample of coal received in Ottawa from the Shand mine near Estevan in the Souris field is given below; and for purposes of comparison, analyses are given of Phalen seam coal from the Sydney field, also of a typical anthracite sold in Ottawa.

TABLE I.

Comparison of Three Coals.

	Shand coal.	Sydney coal.	Anthracite.
Moisture %	34.6	3.5	3.9
Ash %	8.6	5.7	11.2
Volatile matter %	24.9	33.1	4.3
Fixed carbon %	31.9	57.7	80.6
Calorific value, calories per gram.	3795	7510	7005

TABLE II.

Examples of Analyses—Estevan Area Lignite.

—	Estevan Upper Seam.	Estevan Lower Seam, Outcrop Sample.	Roche Percée.	Bienfait-Taylorton Seam.	Bienfait-Taylorton Seam.	Pinto.
Sample number	1427	1425	1445	1446	1438	1450
Proximate analysis:—						
Moisture %	36·5	36·0	34·5	36·3	35·1	35·5
Ash %	7·5	9·8	5·3	5·2	7·0	5·5
Volatile matter %	25·5	25·3	27·2	25·1	25·9	26·8
Fixed carbon %	30·5	28·9	33·0	33·4	32·0	32·2
Sulphur %	0·3	0·9	0·5	0·3	0·4	0·4
Calorific value:—						
Calories per gram	3720	3770	4140	3930	3930	4060
B. Th. U. per lb.	6700	6780	7460	7070	7070	7310
Fuel ratio	1·20	1·15	1·20	1·35	1·25	1·20

Even if we recalculate the calorific value of the Shand coal to a moisture-free basis we get only 5,805 calories per gram.

Table II gives analyses of some other lignites from the Souris, or Estevan Area, coal field.

The low calorific value of the Souris coal is, however, not its chief drawback. The coal as mined consists of large lumps, but contains some 30 per cent of water. Thus for every 100 tons of dry coal shipped, handling charges and freight have also to be paid on some 43 tons of water. Moreover, when the coal is burned in a furnace this water has to be evaporated and sent up the chimney, with a consequent great loss of efficiency. If, on the other hand, the coal is stored, it gradually loses a large part of its contained moisture; but in so doing the lumps crack and crumble until the product is almost useless for ordinary purposes.

Methods for increasing the commercial value of this coal are easy to suggest. For example, it could be dried, powdered, and briquetted. Unfortunately, unlike German brown coal, it is so deficient in inherent binding material that a briquette made without the addition of a binder will not stand storage and handling; whilst briquetting with the addition of a binder is an expensive operation considering the low grade of the material to be treated. The briquettes moreover are so high in volatile constituents that they tend to disintegrate as soon as they are heated. Another suggestion would be to carbonize the coal and use the residue briquetted or otherwise. The volatile matter driven off from the coal by heat has a lower calorific value per gram than has the original coal, so that the residue is a higher grade fuel. The coal, however, does not soften and coalesce when heated, or, in other words, does not coke, so that

the product is a friable material bearing somewhat the same relation to the original that charcoal does to wood. This carbonized residue could be used in gas producers, or as powdered fuel, or, with the addition of a suitable binder, could be briquetted and employed generally as a fuel.

Much work has been done in different parts of the world on the utilization of lignites, and one must conclude from the results obtained that at present the most hopeful treatment for the Souris lignite is low temperature carbonization, and the briquetting of the residue with addition of a binder. In this connexion it may be mentioned that it has long been known to fuel specialists that a truly economical use of most bituminous coals necessitates a preliminary carbonization with recovery of by-products. The importance of this is now very widely understood, and it is reported that the direct combustion of coking coals is prohibited in Germany.

Although, as stated above, much work has been done on the utilization of lignites, comparatively little exact information has yet been published on the carbonization of lignites.

The carbonization experiments have been subdivided into small scale laboratory tests, large scale laboratory tests, and semi-commercial tests. In the first of these, samples of about a quarter of an ounce were taken; this scale of work allowed of very exact control of the conditions of the experiment and also allowed a large number of experiments to be carried out, under widely varying conditions, within a reasonable time. It was not possible, however, to study the by-products. The results are being used to cut down unnecessary work in the larger tests, they are also valuable as checks on the accuracy of control in all subsequent experiments. In the large scale laboratory experiments samples of about five pounds are treated, and all the products are carefully collected and examined.

The semi-commercial tests will follow shortly.

In these carbonization tests the results determined include the yield and calorific value of the carbonized residue; the yield, composition, and calorific value of the gas generated; the yield, calorific value, and economic value of the tar oils produced; and the ammonium sulphate yield available. The conditions under which the lignite is carbonized are varied in order to show the influence on the results of: the final temperature to which the charge is heated, the rate of heating, the pressure in the retort, and the atmosphere in the retort.

The primary object of the investigation is not to design a commercial plant, but to obtain the accurate data essential for the scientific design and control of such a plant. The commercial significance of the results being obtained can readily be seen in connexion with the following points:—

Temperature Control.—Coals are carbonized commercially in retorts operated either intermittently or continuously. Each method has advantages of its own, but the results, especially with regard to tar and gas yields are often markedly different. The coal near the walls of intermittent retorts is heated rapidly and to a high temperature, the coal in the centre of the charge is heated slowly and to a lesser temperature. In continuous retorts all the charge is heated slowly, although there may be the same temperature difference between the centre and the walls. When the best temperature conditions are known it will be possible to design a retort in which they can be approximated. Some variation will, however, probably be necessary for economy of construction, upkeep, and operation, and the data obtained will enable the loss due to the changed temperature treatment to be balanced against the gain in economy.

Pressure in Retort.—Experiments have been and are being carried out under low pressure, atmospheric pressure, and high pressure. It is known that by distilling bituminous coal in vacuo, the tar yield is increased and its nature profoundly changed; it is yet to be determined whether there is any increase in the economic value of

lignite tar thus obtained, commensurate with the increased cost of the process. The high pressure experiments were planned with the idea that the product might require the addition of less binder to form a satisfactory briquette, but this point is yet to be settled. Carbonization of dry lignite under pressure, however, has been shown to give a product of distinctly higher calorific value than normal.

Atmosphere in Retorts.—Steam distillation of oils, etc., is commonly employed as an economical substitute for vacuum distillation. The effect of the atmosphere in both steam and pressure carbonization tests was found to be quite considerable, and the results indicate that this subject will require careful consideration in any commercial scheme.

SMALL SCALE LABORATORY EXPERIMENTS.

Coal.—The particular coal chosen for most of these experiments was from the Shand mine of the Saskatchewan Coal, Brick and Power Co. The sample, which consisted of a single lump of coal shipped by express from the mine in a wooden box, was crushed, and then ground to a fine powder in a ball mill. For convenience of manipulation, and as a prevention against the rapid change which a powdered coal undergoes owing to moisture loss and oxidation, this powder was briquetted in a small hand press. The briquettes were cylindrical, ¼ inch diameter, about ¼ inch long, and ran about 5 or 6 to the gram. They were stored in stoppered weighing bottles until required, and from time to time control moisture determinations were made upon them. It might be noted that during a period of two months the moisture content fell only 1 per cent from an original of over 30 per cent.

The average analysis of this coal was: moisture 31·8 per cent, ash 5·2 per cent, volatile matter 28·9 per cent, and fixed carbon 34·1 per cent. Its gross calorific value was 4,260 per gram.

Apparatus.—The apparatus used for most of the experiments consisted of a cylindrical iron retort 1½ inches high and 1½ inches diameter, inside measurement, having a lid which was held on by a small clamp, the joint being rendered air-tight by means of an asbestos gasket. A small inlet tube was screwed into the bottom of the crucible, and an outlet tube into the lid; the inlet and outlet tubes being so arranged that the retort could be completely immersed in an oil or lead bath. For the experiments under pressure a slightly larger and heavier retort was employed, with a hexagon screw cap and rendered gas-tight with an asbestos-copper gasket. The inlet tube was dispensed with, and a pressure gauge and relief valve connected to the outlet tube

The coal briquettes employed in each test were weighed out into a 10 gram. capacity quartz crucible which fitted inside the iron retort. The heating was done by immersing the retort in a bath, which for tests up to 300° C. was of oil and for those above that temperature of lead. The lead was contained in a 4-inch length of 4-inch iron pipe with a cap end, and was heated in a gas-fired furnace which gave a very uniform temperature throughout the bath, and which permitted of rapid heating and easy control. The temperature was followed by two pyrometers immersed in the lead.

The pyrometers employed were calibrated from time to time by means of the freezing points of lead and zinc. The recorded temperatures are probably correct to within 5°C.

Procedure.—The general procedure, modified in the particular cases noted, was as follows. From 3 to 10 grams of the briquetted sample was weighed out into the quartz crucible, this was placed in the iron retort and the top clamped down. A gentle stream of dried coal gas was passed in through the inlet tube to displace the air, the gas was then cut off and the retort immersed in the bath of oil or lead, previously heated to almost the desired temperature. The progress of carbonization was watched by causing the evolved gas to bubble through a little water; it was thus

found that 1½ hours was sufficient to complete the operation. In every case after the lead bath had been finally adjusted to the desired temperature, this temperature was maintained for at least half an hour. At the end of the experiment the retort was taken out of the bath and cooled as rapidly as possible, cold water being run over it to complete the cooling. A little dried coal gas was also passed through the apparatus during this period to prevent the oxidation of the hot product by air drawn in as the gases contracted. When quite cold the retort was opened and the quartz crucible weighed to determine the loss in weight of the briquettes during the experiment. The calorific value of the carbonized briquettes was then determined by means of a Riche adiabatic calorimeter using a platinum resistance thermometer. Ash and volatile matter determinations were also made in many experiments.

The water content of the original briquettes was determined by heating for one and one-half hours in a toluol oven in a stream of carbon dioxide. By means of this the results obtained above were recalculated to a moisture-free basis.

For reasons given below it was found necessary to standardize the conditions, especially the time factor, in all operations with the dried or carbonized residue. The quartz crucible and contents were always weighed in a stoppered weighing bottle. The residue at the close of an experiment was weighed as soon as cold to determine the loss in weight, and the portion required for the calorimeter was weighed out by difference as nearly as possible fifteen minutes after stopping the heating.

Calculations and curves.—For each test the loss in volatile matter was determined by subtracting the weight of the moisture in the sample taken from the observed loss, the result being expressed as a percentage of the equivalent weight of dry coal. This is referred to as the percentage loss of weight (volatile matter) on a moisture-free basis. It should be noted that water originally present in the coal is not regarded as volatile matter in the technical use of that phrase, although water produced by the decomposition of the coal is included in the volatile matter.

In diagram I the loss of volatile matter is shown plotted against the temperature at which the experiment was carried out; a separate curve being shown for each of the series of tests described below. In a few cases the points given represent the average of two or more results. Diagram I also shows the calorific value of the carbonized residue from each test, these values being similarly plotted against the temperature of carbonization.

Diagram II shows the calorific value of the carbonized residue plotted against the yield; the yields being shown as percentages of both the original coal and the moisture-free coal. These curves are also deduced from the rounded curves in diagram I.

Table III shows the summarized results of all the tests. For ease of comparison, the results given are taken from the rounded curves in the diagrams at definite temperature intervals.

All results have been calculated to a moisture-free basis as described above. This gives a more stable basis for comparison, as the moisture in the coal as received is liable to show considerable variation. It is also a more satisfactory basis when it is desired to compare results with coals from different sources.

The residue from a moisture determination, in an atmosphere of carbon dioxide in a toluol oven, is taken as the moisture-free basis for all calculations and curves, it being assumed that no volatile matter is driven off at 110°C.

Regular Series of Tests on Shand Coal.—Nine completed tests were run in this series over a temperature range of from 200° C., to 700° C., the general procedure given above being followed. In addition, moisture determinations in the toluol oven were regarded as giving the comparable results for a temperature of 110° C., and standard volatile matter determinations, in a platinum crucible over a gas flame, the results for a temperature of approximately 900° C.

The results obtained, as shown in the curves, indicate that the loss of volatile matter is slight up to 300° C., from there up to 600° C., the loss increases rapidly, and by 700°C. the volatile matter has nearly all been driven off. The calorific value of the residue increases steadily up to 500°-600°C., and then commences to decrease.

A very striking phenonemon, first observed in connexion with the vacuum series, was later found to take place with every sample of dried or carbonized lignite. The residue in every case rapidly gained in weight after removal from the retort, even when stored in a desiccator over sulphuric acid, its calorific value at the same time decreasing. This was later shown to be mainly due to occlusion of air. The results given in the curves and in the tables are, with the exceptions noted, for weights and calorific values determined immediately after the experiment.

Slow Carbonization Series on Shand Coal.—Six completed tests were run in this series over a temperature range of from 390° C. to 700° C. The procedure was the same as in the regular series, except that, instead of the retort being heated rapidly up to the desired temperature, it was first heated to about 250° C. in the oil bath, then transferred to the lead bath, and its temperature slowly raised to the required point.

The results show a strong similarity to those of the regular series, but for any given final temperature, slow heating caused a slightly lower loss of volatile matter. The calorific values were rather erratic but showed no marked difference from the above. It should be noted in this and the following cases, that even where the yields and the calorific values are similar in two series, it is no indication that the by-products are also alike. As has already been stated, the by-products are to be examined in a later investigation.

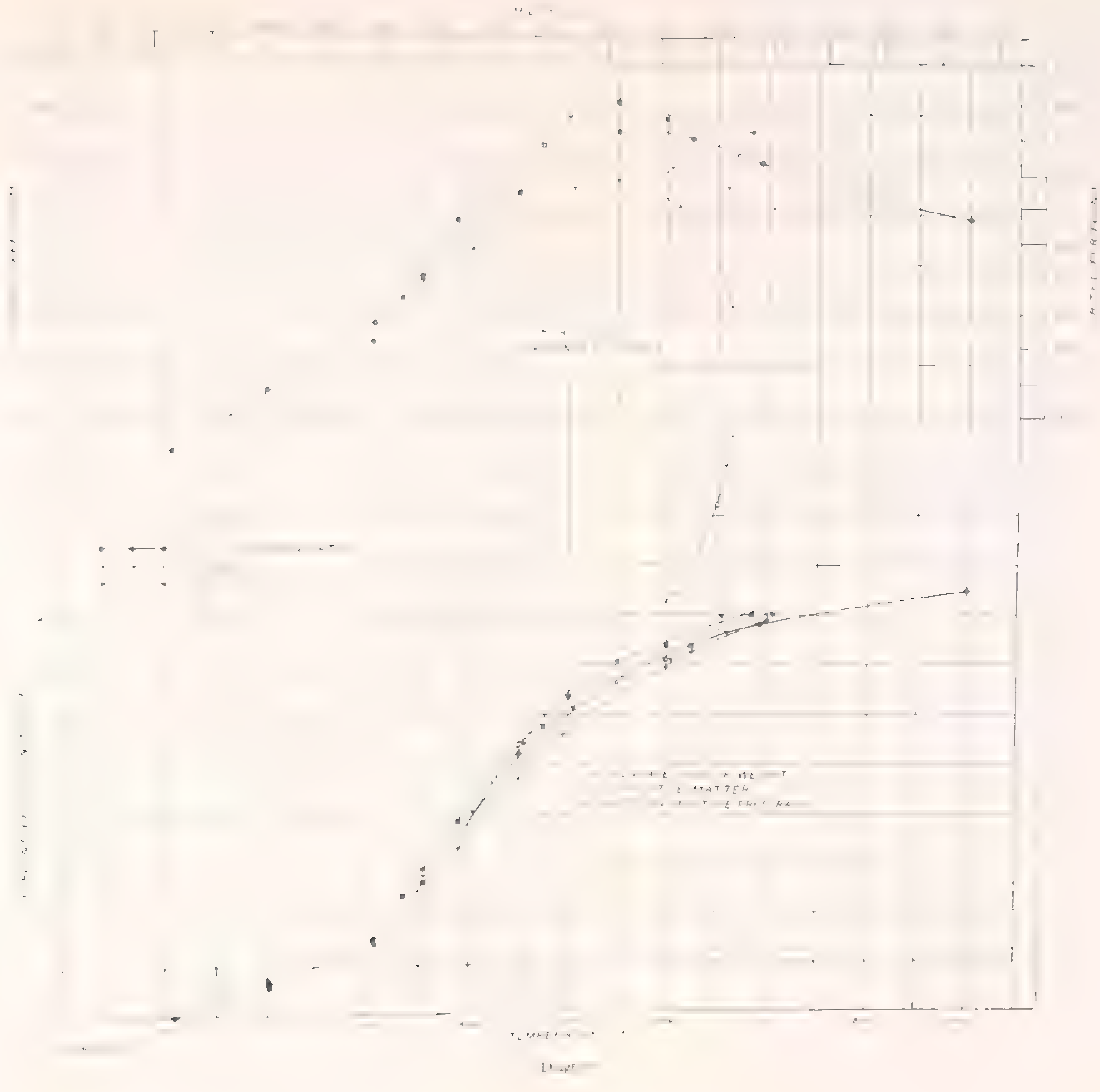
This series was not repeated after standardization of the time factor. The calorific values obtained were therefore omitted from the curves and tables.

Vacuum Series on Shand Coal.—Eight completed tests were run in this series over a temperature range of from 355° C. to 705° C. The procedure differed from the regular in that the inlet tube of the retort was closed, and the outlet tube connected through a receiver to a good water pump; the pressure in the retort being thus kept below 25 mm. of mercury.

The results show, as was expected, that at any temperature the percentage of volatile matter driven off is greater than at ordinary pressures; but the difference is not so great as was expected. The calorific value of the residue is the same as in the regular series at 350° C., above this temperature it is distinctly less.

Steam Series on Shand Coal.—Six completed tests were run in this series over a temperature range of from 355° C. to 655° C. The general procedure was followed, except that a gentle current of steam was passed in through the inlet tube whilst the retort was being heated, dry coal gas being passed through as usual during the cooling period.

The results were similar to those of the regular and vacuum series up to a temperature of about 450° C. Above this temperature a secondary action appears to influence the results, this being very marked above 600° C. This disturbing influence is no doubt the chemical reaction, well known in connexion with gas producers, between steam and carbonaceous matter, whereby carbon dioxide, carbon monoxide, and hydrogen are produced, and the yield and calorific value of the residue decreased. It is quite obvious that the results actually obtained in this series were dependent on the quantity of steam passed through and the duration of the heating. That fairly smooth curves were obtained was due merely to the fact that the quantity of steam and the time of heating were approximately the same in each case. If these had been sufficiently increased, at any rate at the higher temperatures, the coal would have been burned to ash.



The calorific values shown in the curves were not determined immediately after the experiment. The results to be obtained are so dependent on the quantity of steam passed through, that it was not thought necessary to repeat this series according to the later standardized method. The yield curve is probably correct as it stands, but the calorific value curve, and the results deduced therefrom, are probably uniformly two or three per cent too low.

Pressure Series on Shand Coal.—Eight completed tests were run in this series over a temperature range of from 335° C. to 685° C. The special retort described above was employed, and the general procedure was modified in that the retort was closed so that the volatile products could not escape. When the charge was first heated the pressure rose rapidly to above 120 pounds per square inch, but the relief valve being opened as required the pressure was reduced and maintained as close to that figure as possible. At the end of the experiment the retort was cooled with the valve shut.

Trouble was experienced in this series from the water in the coal. In the first place it volatilized and created a big initial pressure; and then, after this had been relieved by the valve, the steam still remaining in the retort gradually passed into the exit tube and condensed, causing the pressure in the system to fall below the desired minimum. In the second place, the steam in the retort reacted with the coal as described in the previous series, and masked the results it was desired to study. Seven experiments in this series were therefore carried out using coal briquettes previously dried in carbon dioxide in a toluol oven. In one experiment at 335° C. moist coal was used, the steam effect at that temperature being negligible.

The results are remarkable in that they agree most closely with those of the vacuum series. The calorific values, however, are distinctly higher than in any other series, reaching a maximum at about 550° C. and then rapidly falling off.

TABLE III.

Carbonization of Shand Lignite—Small Scale Laboratory Experiments. Summary of Results.

Temperature of Carbonization. °C.	Regular.			Vacuum.			Steam.			Pressure.		
	Yield of residue.	Calorific value.	Thermal efficiency.	Yield of residue.	Calorific value.	Thermal efficiency.	Yield of residue.	Calorific value.	Thermal efficiency.	Yield of residue.	Calorific value.	Thermal efficiency.
110	100·0	$6,260	100·0	–	–	–	–	–	–	–	–	–
200	96·8	6,485	100·3	–	–	–	–	–	–	–	–	–
300	92·8	6,750	100·0	–	–	–	–	–	–	–	–	–
350	87·4	6,920	96·6	86·3	6,920	95·4	89·8	6,850	98·3	86·0	6,960	95·6
400	80·5	7,110	91·4	79·6	7,045	89·6	81·0	6,970	90·2	79·0	7,205	90·9
450	74·2	7,280	86·3	73·5	7,170	84·2	72·8	7,090	82·4	73·1	7,400	86·4
500	70·0	7,435	83·1	69·5	7,280	80·8	67·8	7,200	78·0	68·4	7,575	82·8
550	66·8	7,530	80·4	66·5	7,355	78·1	63·4	7,285	73·8	65·0	7,640	79·3
600	64·2	7,520	77·1	63·7	7,365	74·9	58·7	7,255	68·0	62·8	7,595	76·2
650	62·1	7,470	74·1	61·5	7,315	71·9	49·0	7,000	54·8	60·9	7,550	73·4
700	60·8	7,390	71·8	59·8	7,230	69·1	–	–	–	59·2	7,515	71·1
800	59·1	7,270	68·6	–	–	–	–	–	–	–	–	–
900	57·7	7,180	66·2	–	–	–	–	–	–	–	–	–

NOTE:—The yield is the weight of the residue as a percentage of the moisture free coal. Calorific values are given in calories per gram of residue. The thermal efficiency is the heat value of the residue as a percentage of the total heat value of the original sample.

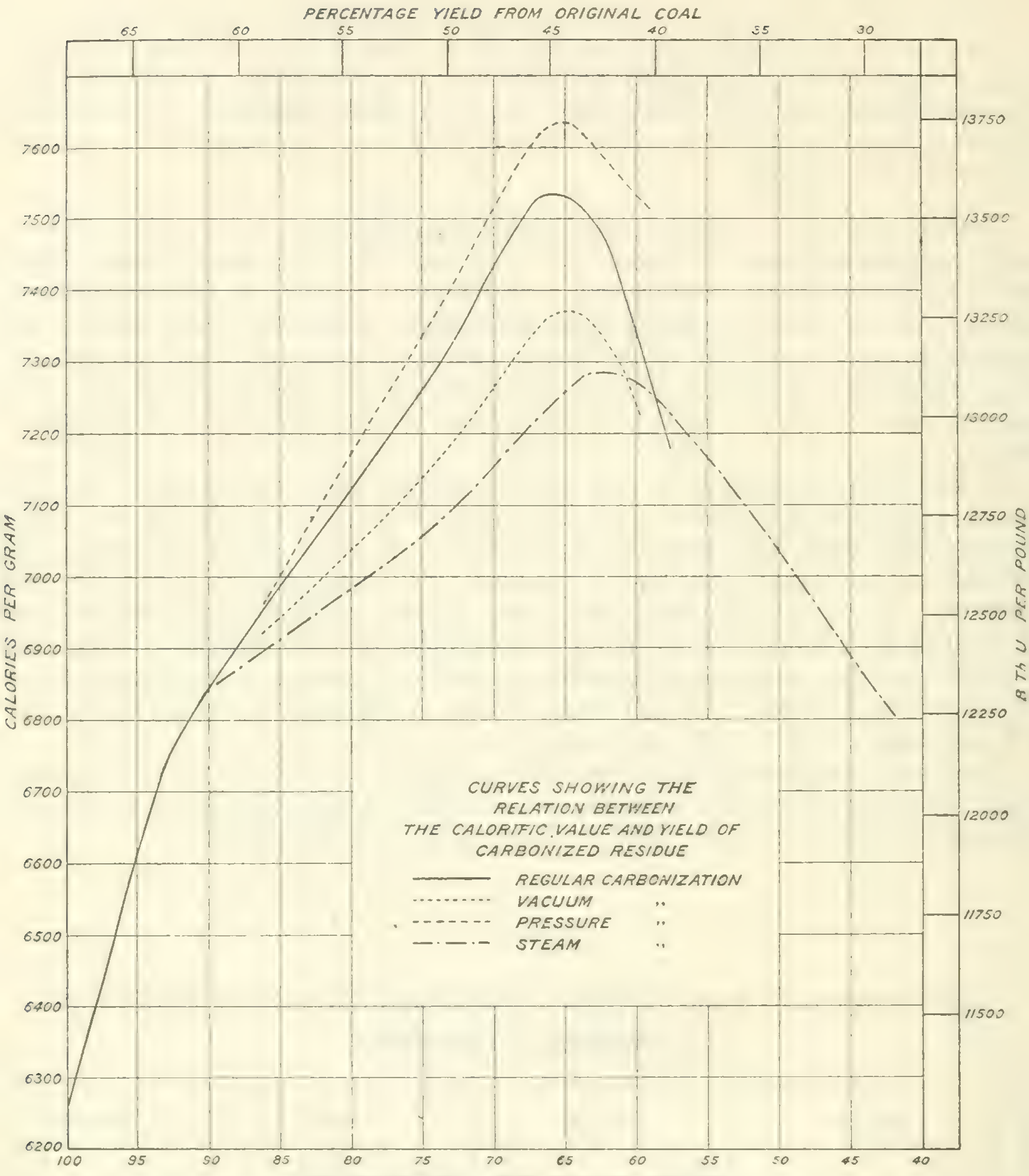


Diagram II.

Regular Series on other Lignites.—Comparative tests have been made on lignite samples from the West Dominion Collieries, Taylorton, Sask.; Wm. Halberts mine, Trochu, Alta.; and Cardiff Collieries, Cardiff, Alta. The procedure followed was that described under "Regular Series on Shand Coal." Diagrams III, IV, V, and VI show in comparable form the results obtained with the Shand coal and the three coals enumerated above. In these curves the calorific value of the residue, and also its percentage content of moisture, ash, and volatile matter, are shown plotted against the percentage yields on the basis both of coal as charged and of dry coal. The temperatures of carbonization at which the different yields are obtained are also shown. No determinations of ash and volatile matter were made in the experiments with Shand lignite, the curves shown for these are therefore theoretical. With the other three samples these determinations were made, and both the theoretical and determined curves are shown. It will be noted that the determined ash is always lower than that calculated from the loss in weight. The relation between the determined and the calculated volatile matter is less regular, but generally the former is the lower.

Tests on lignites from other fields are now in progress.

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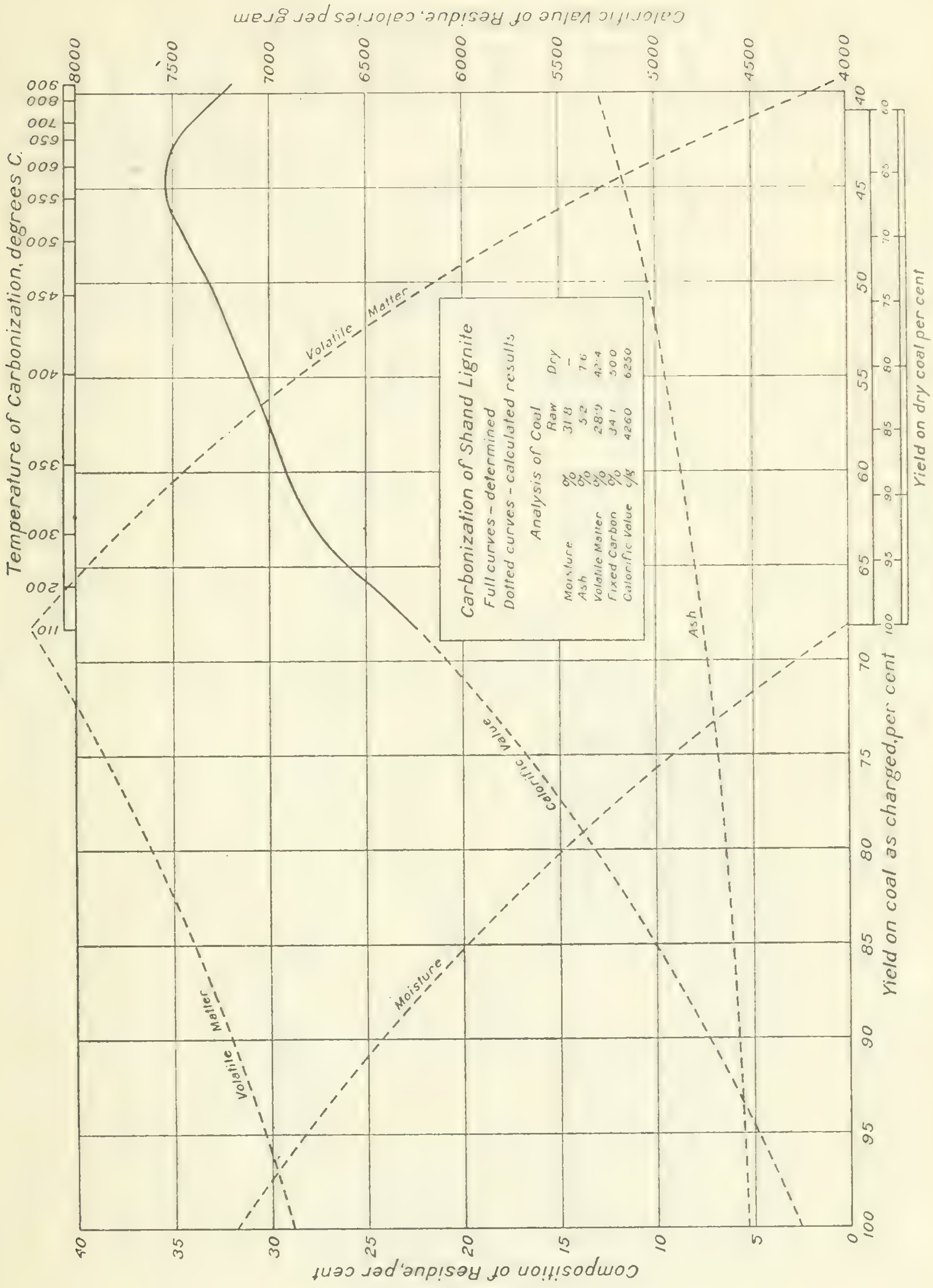


Diagram III.

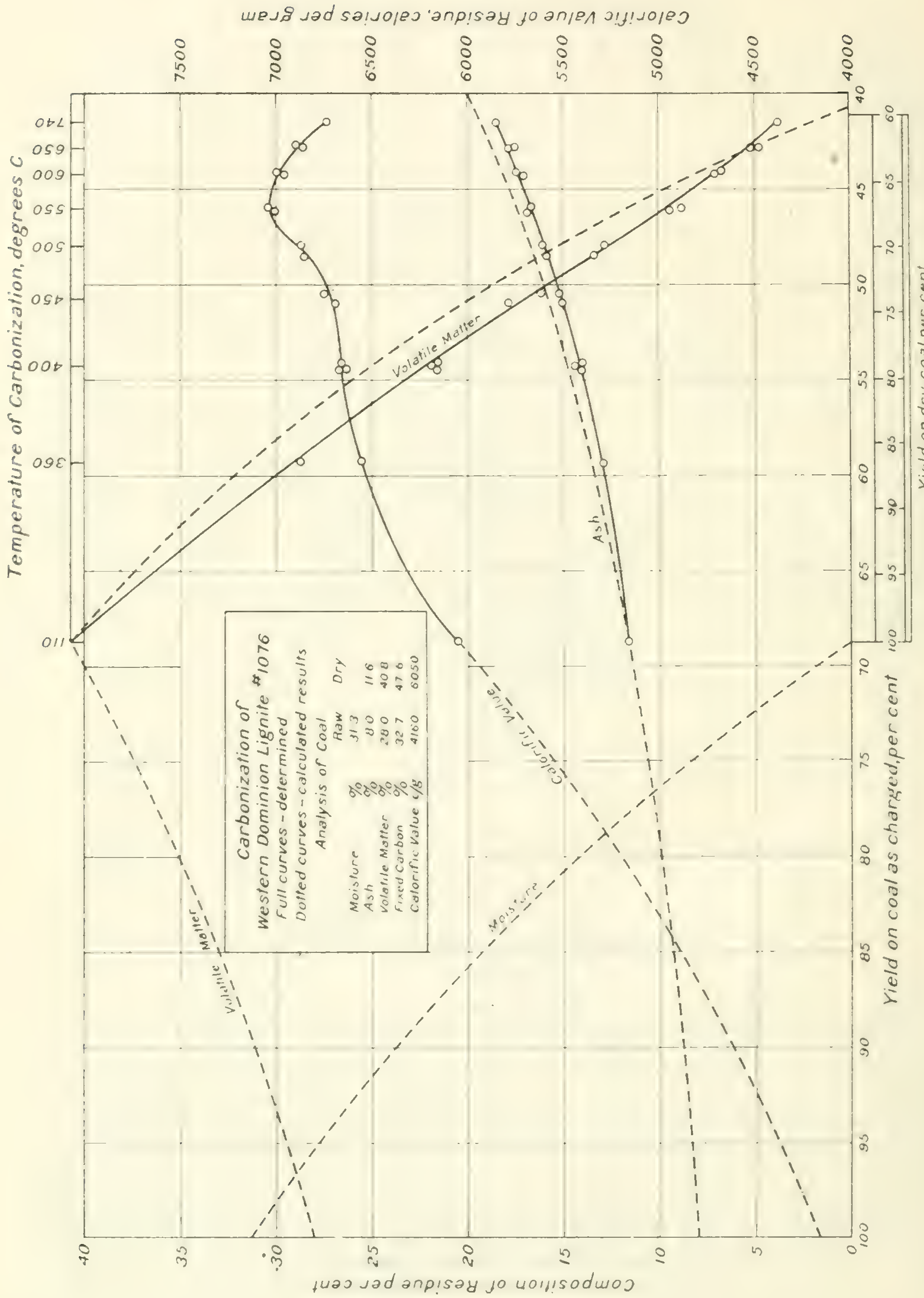

Calorific Value of Residue, calories per gram
Temperature of Carbonization, degrees C
Composition of Residue per cent
Yield on coal as charged, per cent
Yield on dry coal per cent
Carbonization of
Western Dominion Lignite #1076
Full curves - determined
Dotted curves - calculated results
Analysis of Coal Raw Dry
Moisture % 31.3
Ash % 8.0 11.6
Volatile Matter % 28.0 40.8
Fixed Carbon % 32.7 47.6
Calorific Value c/g 4160 6050
Volatile Matter
Calorific Value
Moisture
Ash

Diagram IV.

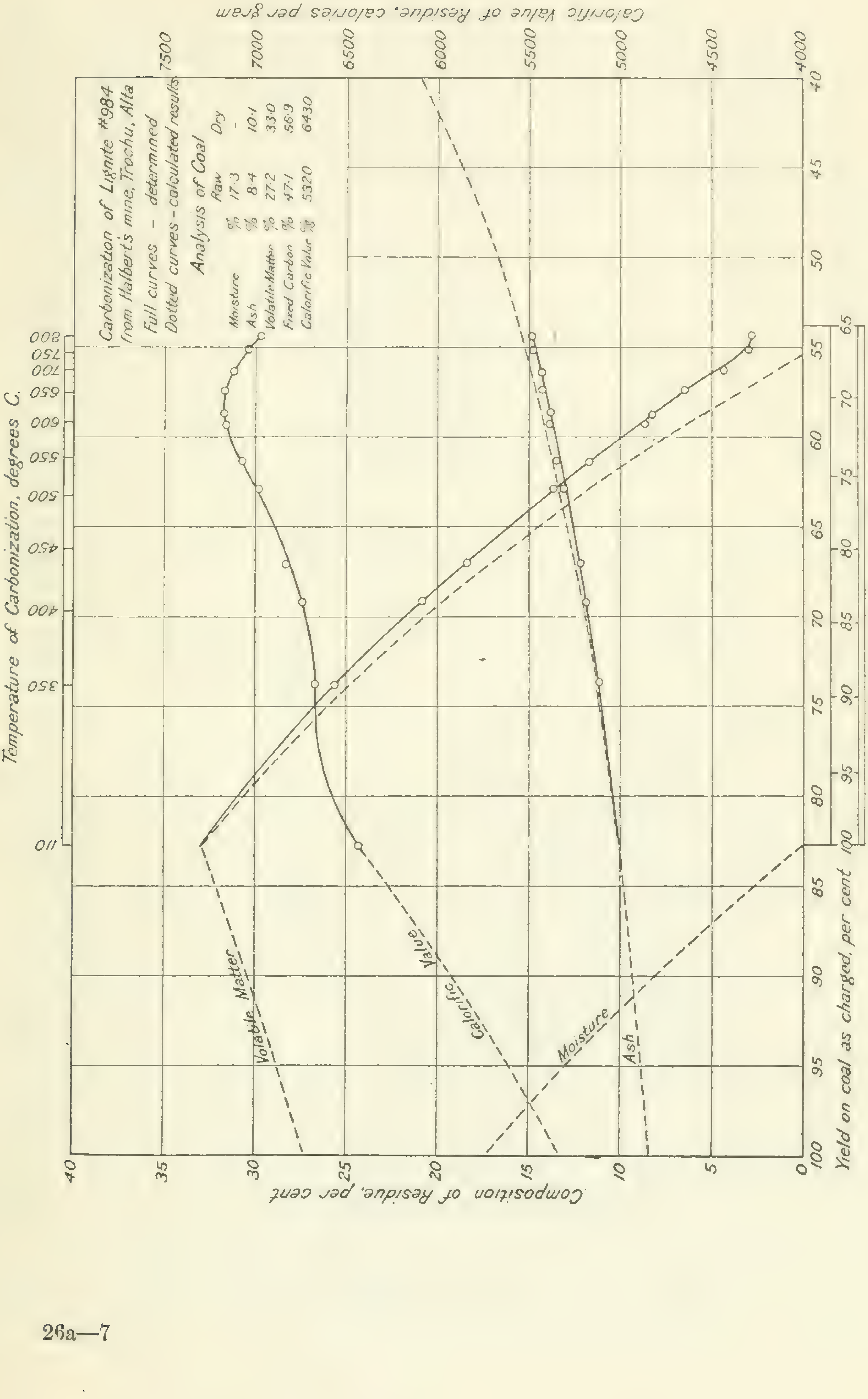

Carbonization of Lignite #984
from Halbert's mine, Trochu, Alta
Full curves - determined
Dotted curves - calculated results
Analysis of Coal
Raw Dry
Moisture % 17·3 -
Ash % 8·4 10·1
Volatile Matter % 27·2 33·0
Fixed Carbon % 47·1 56·9
Calorific Value % 5320 6430
Temperature of Carbonization, degrees C.
Calorific Value of Residue, calories per gram
Composition of Residue, per cent
Yield on coal as charged, per cent
Yield on dry coal, per cent
Volatile Matter
Calorific Value
Moisture
Ash

Diagram V

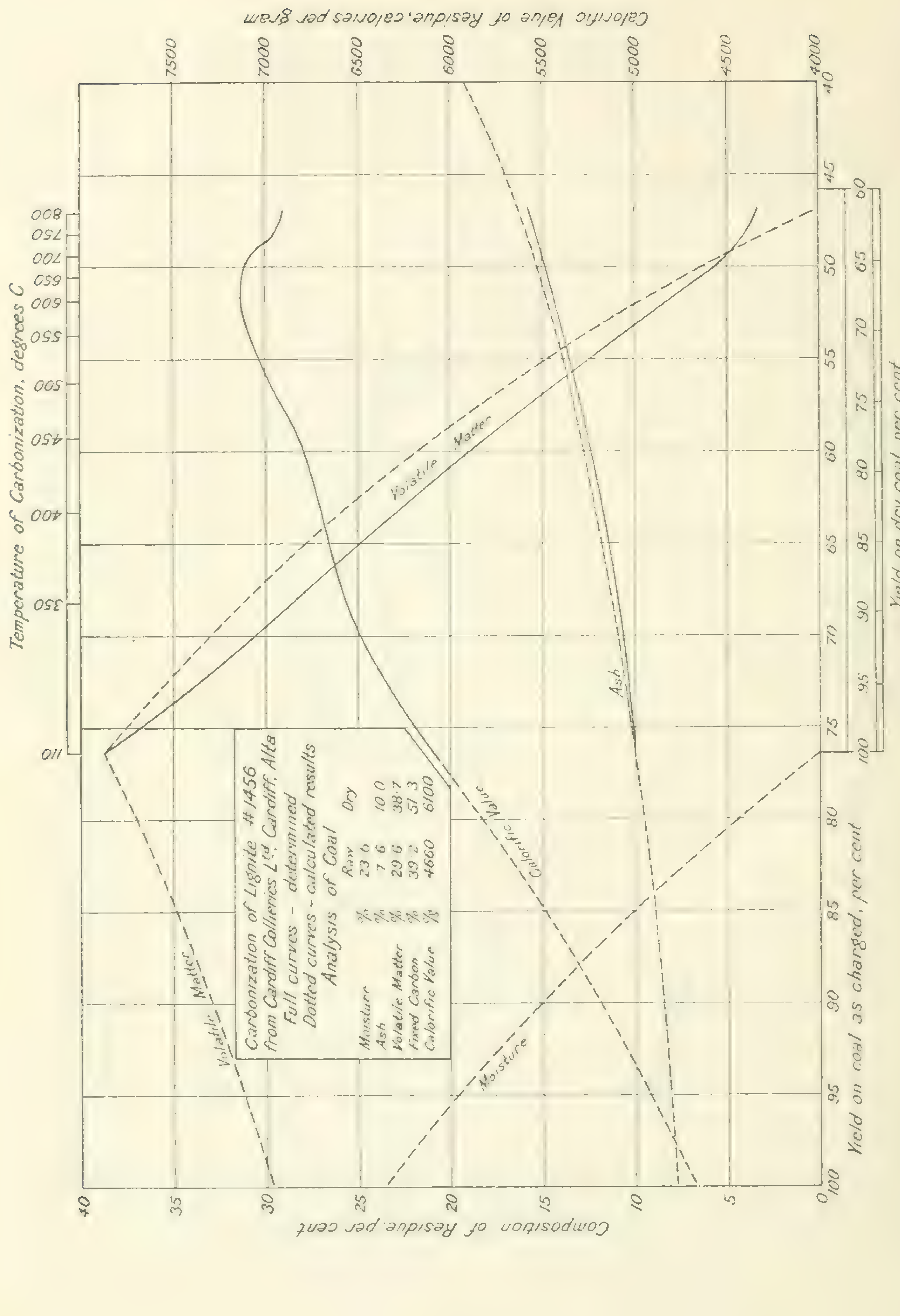

Carbonization of Lignite #1456
from Cardiff Collieries Ltd, Cardiff, Alta
Full curves - determined
Dotted curves - calculated results
Analysis of Coal
Raw Dry
Moisture % 23.6
Ash % 7.6 10.0
Volatile Matter % 29.6 38.7
Fixed Carbon % 39.2 51.3
Calorific Value % 4660 6100
Temperature of Carbonization, degrees C
Calorific Value of Residue, calories per gram
Composition of Residue, per cent
Yield on coal as charged, per cent
Yield on dry coal, per cent
Volatile Matter
Ash
Calorific Value
Moisture

Diagram VI.

LARGE SCALE LABORATORY EXPERIMENTS.

In the small scale experiments only the residue left from the carbonization of lignite under specified conditions was studied, and its yield, calorific value and analysis determined. In the large scale laboratory experiments the results determined include the yield and calorific value of the carbonized residue; the yield, composition, and calorific value of the gas generated; the yield, calorific value, and economic value of the tar oils produced; and the ammonium sulphate yield available. The conditions under which the lignite was carbonized were, in the experiments here described, only varied to show the influence on the results of the final temperature to which the charge is heated, the rate of heating, and the moisture condition of the coal treatment. Further experiments are well under way which show the effect of the pressure in the retort and the atmosphere in the retort.

Apparatus.—The apparatus designed for and employed in most of these tests embodies three important features: an accurate temperature control; the reduction, as far as possible, of the temperature lag from the walls to the centre of the charge; and the complete removal and easy collection of the tar vapours. The general layout of the apparatus is shown diagrammatically in Fig. 5.

The temperature control is effected by the use of an electrically heated lead bath, B, with suitable thermal insulation. The bath rests on a movable platform which can be raised by a screw C. The temperature is observed by means of a pyrometer and regulated by switches and a rheostat.

The reduction of lag is effected by the use of a tubular retort A. This consists of seven 12″ lengths of 2″ boiler tubing, mounted into a cast iron head. No part of the charge is thus more than 1″ from the walls of the retort, which has a capacity, to the top of the tubes, of 2,300 grams of pea size lignite with about 35 per cent moisture content.

A satisfactory method for collecting the tar was only evolved after many weeks of work and many failures. Not only was it hard to remove the last traces of tar fog, but the condensate was usually in the form of a watery emulsion, very difficult to handle.

The method employed is as follows: the hot gases leaving the retort pass down through the centre tube of a small scrubber D, made of iron pipe and containing three interlacing coils of wire, passing up again through a surrounding annular space; the whole being jacketed with superheated steam. The heavy tar oils are here condensed in a practically water free condition, and drop into a weighed glass beaker. The lighter oils, steam, and gases pass on and down through a simple tubular condenser E where the two former condense and collect in a receiver, the oils floating on the water and showing only a slight tendency to emulsify. The cool gases leaving the condenser still contain some tar fog; they are therefore passed down through a tube scrubber F filled with glass beads (and a short layer of glass wool shown shaded) through which a jet of steam from a weighed boiler is also passed. The bottom half of this scrubber is water cooled. This scrubber completely removes the tar fog from the gas; the oil first condensed on the beads acts as an oil scrubber collecting more of the tar, the steam prevents the clogging of the scrubber by keeping the tar hot and fluid, and also, when condensing at the bottom, carries down with it any vapours still remaining. The gases are thus completely cleaned, and all the liquid products as well as the ammonia from the lignite are collected in the vessels and can be readily weighed and examined. The tar oils thus collected are reasonably free from water and can be redistilled without excessive bumping or frothing. The gases leaving the scrubber F pass through a final cooling tube G, through a gas meter H, and into a gas holder which is not shown.

For temperatures above 700° C. a smaller apparatus was employed, and no lead bath. The retort consisted of a simple piece of 3″ boiler tube 16″ long. It was heated by placing it inside a tube of 3″ bore heated electrically by means of coils of

nichrome wire wound round the outside. A charge of 1,000 grams was taken for all experiments with this retort. The temperature of the lignite was observed by means of two pyrometers, one in the centre and one near the wall of the retort, about 5″ or 6″ from the bottom. As lignite shrinks during carbonization the pyrometers were approximately in the centre of the mass at the end of an experiment. The temperature was found to be fairly uniform throughout the charge, but the control is not as exact as with the lead bath heater; this is indicated in the temperature column in the tables.

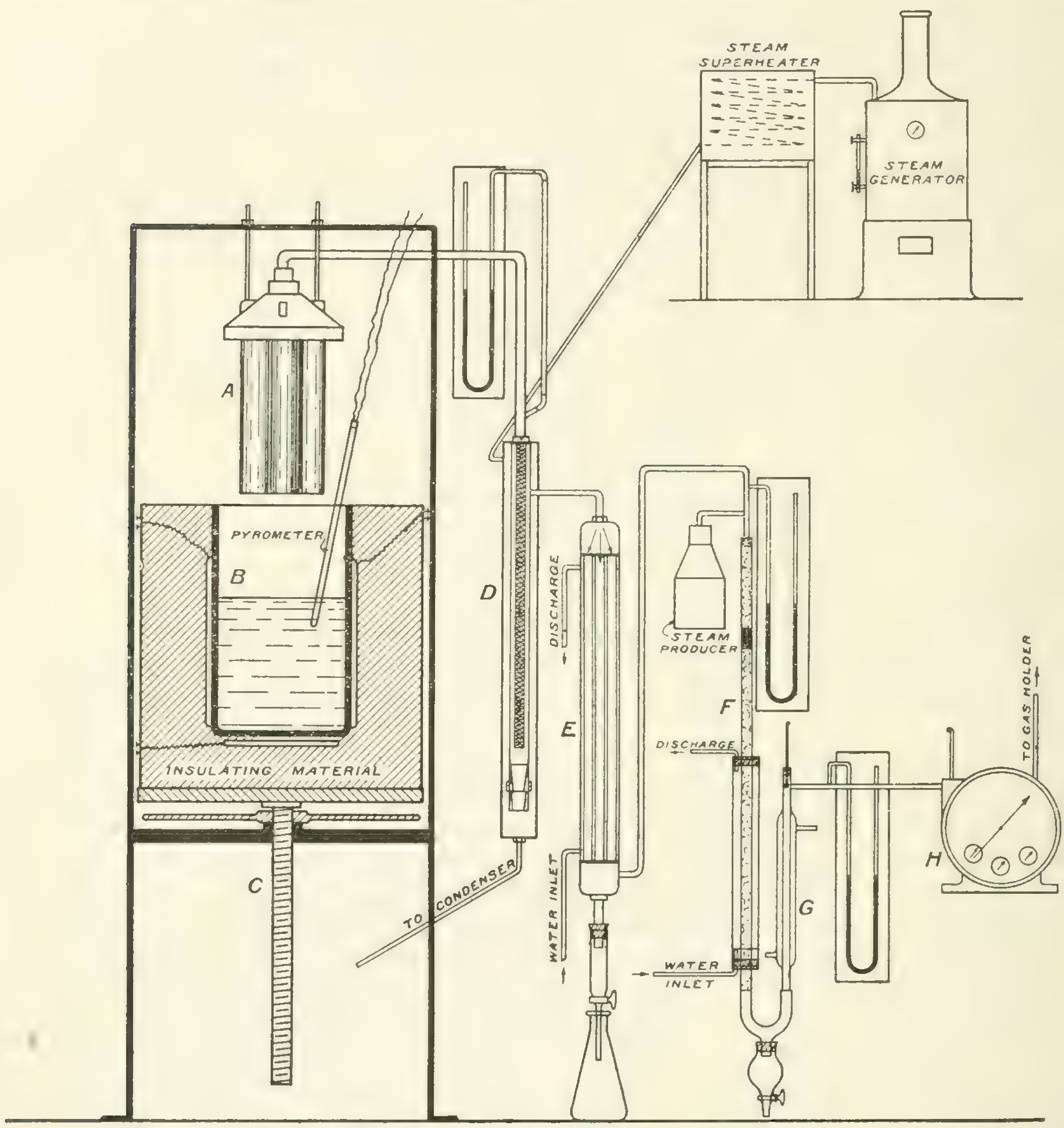


Fig. 5.—Apparatus for lignite carbonization.

The gases and vapours leaving the retort were treated in the apparatus already described, with the exception that the first condenser D was omitted on account of the smaller quantity of gas to be treated. The effect of this omission of fractional condensation is shown in the high moisture content of the crude tar oils as given in table X.

Regular Series of Tests, Rapid Heating.—In the experiments the retort was charged, usually with pea-sized lignite containing about 34 per cent moisture, but in a few experiments with dried lignite, and connected to the purifying train which was then swept out with gas from a previous run. The lead bath, heated to temperature

higher than that desired for the test in order to allow for the cooling effect of the retort, was then raised to surround the retort. The temperatures and pressures at the different parts of the system, and also the meter readings, were recorded at frequent intervals, and the experiment continued until the evolution of gas had practically ceased. The volumes of gas collected were corrected for temperature, pressure and moisture content, being reduced to moist gas at 60° F. and 30″ of mercury pressure. All other products were weighed, and all the products were carefully analysed. In a number of the experiments the gas was collected in two separate holders, and the two portions were then analysed separately; it will be noted that the gas from the second half of the run is much richer than that collected in the first holder.

The tables given below summarize the more important results obtained. As a general rule the results are the average of two or more experiments at each temperature.

Slow Heating Series of Tests.—In the slow series the general method was the same as the above, except that the lead bath was only heated beforehand to a temperature slightly above the melting point of the lead. The bath was then raised slowly up and, after the retort was immersed, the temperature then slowly raised to the temperature of the test.

Experimental Results.—The results obtained in the experimental work are summarized in the following tables:—

Table IV gives a typical analysis of the Shand coal employed in the tests.

TABLE IV.

Typical Analysis of Shand Coal Employed in Tests.

Proximate analysis.		Coal as charged	Dry coal.
Proximate analysis—			
Moisture	%	32·6	0·0
Ash	%	8·6	12·8
Volatile matter	%	27·1	40·2
Fixed carbon	%	31·7	47·0
Calorific value—			
Calories per gram		3965	5880
B. Th. U. per lb		7140	10580
Fuel ratio		1·17	1·17

Table V gives analyses of another sample of Shand coal, as mined with 35 per cent of water, after drying at 110° C., after carbonizing at 580°-600° C., and after carbonizing at 775°-800°C. Table VI gives a weight balance sheet on carbonization; the last column indicates the accuracy obtained. Table VII gives the commercial products obtained per ton of moist coal charged. Table VIII gives a thermal balance sheet; the last column gives the heat lost through the formation of water, carbon dioxide, etc., during carbonization. Table IX gives yields and analyses of the carbonized residue. Table X gives yields, analyses and distillation tests on the tar oils. In the last column the quantity of pitch available for use as a binder for briquetting the carbonized residue is shown. Table XI gives the yields, and combustible content of the gas produced. In most of the experiments the gas was collected in two approximately equal portions; it can be seen that the second portion was far richer than the first.

Table XII gives some comparative results on different samples of lignite from the Estevan area. Six samples were tested from five different mines at Taylorton, Bienfait, Shand, and Estevan; one sample consisted of outcrop coal. The samples were carbonized as described above under "Regular Series of Tests, Rapid Heating," at a temperature of 575°-600° C. In the results obtained comparisons between the different

coals were masked by variations in the moisture and ash content of the samples tested. The results were therefore recalculated to the uniform basis of coals containing 33 per cent moisture and 7 per cent ash. The table shows that in the main the different coals of this field give closely agreeing results, after allowing for variations caused by differences in moisture and ash content. The yields of tar, however, are a marked exception in this respect.

TABLE V.

Analyses Shand Coal—Raw, Dried, and Carbonized.

Sample.		As mined.	Dried.	Carbonized at 580-600°C	Carbonized at 775-800°C
Proximate analysis—					
Moisture	%	35·0			
Ash	%	8·1	12·5	17·5	20·3
Volatile matter	%	25·5	39·2	11·7	2·8
Fixed carbon	%	31·4	48·3	70·8	76·9
Ultimate analysis—					
Carbon	%	40·6	62·5	74·0	76·6
Hydrogen	%	6·5	3·9	2·4	1·0
Ash	%	8·1	12·5	17·5	20·3
Sulphur, Nitrogen, Oxygen	%	44·8	21·1	6·1	2·1
Calorific value—					
Calories per gram		3700	5690	6620	6560
B. Th. U. per lb		6660	10240	11920	11800
Fuel ratio		1·25	1·25	6·05	27·80
Carbon-hydrogen ratio		6·2	16·1	30·8	77·4

TABLE VI.

Weight Balance Sheet, Lignite Carbonization—Dry Coal Basis.

Temperature.	Water of decomposition.	Gas.	Tar oils, crude.	Carbonized residue.	Unaccounted for.
	%	%	%	%	%
Rapid heating—					
350°C	6·9	4·1	1·0	87·5	-0·5
400°	9·8	8·1	2·9	79·1	-0·1
475	11·9	12·3	4·2	71·4	-0·2
555	11·7	17·0	4·1	66·7	-0·5
605	13·4	18·0	4·2	64·3	-0·1
690	12·5	22·1	3·9	61·5	0·0
Rapid heating, no lead bath—					
750-800°C	13·5	21·7	3·7	60·8	-0·3
Rapid heating, dried coal—					
550°C	8·7	17·9	3·4	69·6	-0·4
Rapid heating, dried coal, no lead bath—					
750-800°C	9·1	22·4	3·0	65·4	+0·9
900-950	8·3	25·1	3·0	63·9	+0·3
Slow heating—					
450°C	10·4	11·5	4·3	74·0	+0·2
550	12·6	15·5	4·5	67·4	0·0
655	12·4	20·2	4·0	63·8	+0·4

TABLE VII.

Commercial Products, Lignite Carbonization—Moist Coal as Charged.

Temperature.	Moisture as charged.	Yields per short ton.			
		Gas.	Ammonium sulphate.	Tar oils.	Carbonized residue.
	%	c. f.	lbs.	gals.	lbs.
Rapid heating—					
350°C	32·3	590	0·5	0·1	1185
400	31·9	1190	1·4	4·1	1075
475	31·6	2020	4·4	5·4	980
555	31·8	3130	10·2	5·3	910
605	31·2	3810	11·8	5·6	885
690	33·0	4900	19 2	5·0	825
Rapid heating, no lead bath—					
750-800°C	33·7	5530	15·0	4·0	804
Rapid heating, dried coal—					
550°C	2·3	3010*	10·5	4·6*	935*
Rapid heating, dried coal, no lead bath.					
750-800°C	1·5	4880*	16·8*	3·0*	867*
900-950	2·2	5920*	16·2*	2·8*	834*
Slow heating—					
450°C	33·1	1710	3·3	5·3	990
550	34·0	2750	10·4	5 9	890
655	33·6	4200	14·5	5·1	845

*Calculated to the yield from a 33% moisture charge for comparison.

TABLE VIII.

Thermal Balance Sheet, Lignite Carbonization—Heat Content of Products as Percentages of Heat in Original Charges.

Temperature.	Gas.	Tar.	Carbonized residue.	Loss.
	%	%	%	%
Rapid heating—				
350°C	0·7	1·6	92·2	5·5
400	1·7	4·7	88·3	5·3
475	5·0	6·7	81·7	6·6
555	8·3	6·0	78 1	7·6
605	10·6	6 5	74·8	8·1
690	14·4	5·9	70·4	9·3
Rapid heating, no lead bath—				
750-800°C	14·7	4·6	68·5	12·2
Rapid heating, dried coal—				
550°C	7·5	5·5	81·1	5·9
Rapid heating, dried coal, no lead bath—				
750-800°C	13·6	3·8	76·3	6·3
900-950	17·4	3·5	73·0	6·1
Slow heating—				
450°C	4·1	6·3	83·7	5·9
550	8·0	7·2	79·0	5·8
655	12·5	6·2	73·7	7·6

TABLE IX.

Carbonized Residue—Lignite Carbonization.

Temperature.	Yield of coal as charged.	Water in coal as charged.	Ash content.	Calorific value.	
				Calories per gram.	B. Th. U. per lb.
	%	%	%		
Rapid heating—					
350°C	59·2	32·3	15·6	6195	11150
400	53·8	31·9	15·0	6564	11815
475	48·8	31·6	15·9	6727	12110
555	45·5	31·8	16·9	6882	12390
605	44·2	31·2	17·6	6845	12320
690	41·3	33·0	20·1	6729	12110
Rapid heating, no lead bath—					
750–800°C	40·2	33·7	16·3	6815	12270
Rapid heating, dried coal—					
550°C	68·0	2·3	18·4	6848	12325
Rapid heating, dried coal, no lead bath—					
750–800°C	64·4	1·5	26·4	6495	11690
900–950	63·1	2·2	19·8	6566	11720
Slow heating—					
450°C	49·5	33·1	16·9	6645	11960
550	44·4	34·0	18·5	6895	12410
655	42·3	33·6	18·5	6790	12220

TABLE X.

Tar Results—Lignite Carbonization.

Crude tar oil.			Dried tar oil.				
Temperature.	Water content.	Density.	Yield per 2000 lbs. dry coal.	Calorific value B. Th. U. per lb.	Distillation results.		Pitch as per cent of carbonized residue.
					Up to 310°C.	Pitch residue.	
	%		gals.		%	%	%
Rapid heating—							
400°C	1·5	0·98	6·0	17,260	60·9	38·1	1·4
475	7·7	0·99	7·9	17,250	55·6	42·9	2·3
555	9·4	1·00	7·5	17,040	64·2*	34·7*	1·9
605	3·3	1·00	8·1	17,030	53·7	43·4	2·7
690	5·2	1·00	7·3	16,970	65·2	32·5	2·0
Rapid heating, no lead bath—							
750–800°C	22·8†	1·01	5·8	17,100	42·6	57·1	2·7
Rapid heating, dried coal—							
550°C	2·3	0·97	6·9	17,410	58·6	40·7	2·0
Rapid heating, dried coal, no lead bath—							
750–800°C	31·0†	0·98	4·6	17,130	42·0	56·5	1·9
900–950	31·3†	0.99	4·2	17,280	40·5	58·7	1·9
Slow heating—							
450°C	9·6	0·99	7·8	17,110	62·7	36·2	1·9
550	1·8	0·99	8·9	17,020	60·5	38·3	2·5
655	6·6	0·99	7·6	17,560	60 0	38·5	2·3

*Cut at 325°C. †Small scale experiment, fractional condensation of tar not employed.

TABLE XI.

Gas Results—Lignite Carbonization.

Temperature.	Yield per 2000 lbs. dry coal.	Calorific value B. Th. U. per c. f.		Density.	Combustible gas.		Average.
		gross.	net.		Holder (1)	Holder (2)	
	c. f.				%	%	%
Rapid heating—							
350°C	870	180	170	1·22	28	....	28
400	1740	215	195	1·24	29	....	29
475	2950	355	320	0·96	46	....	46
555	4590	385	345	0·94	49	70	55
605	5530	405	365	0·86	52	75	61
690	7320	415	375	0·79	51	82	67
Rapid heating, no lead bath—							
750-800°C	8340	369	330	0·69	65	....	65
Rapid heating, dried coal—							
550°C	4490	355	320	1·02	36	67	49
Rapid heating, dried coal, no lead bath—							
750-800°C	7350	373	335	0·81	43	75	63
900-950	9085	381	341	0·71	58	83	73
Slow heating—							
450°C	2560	340	310	1·17	39	....	39
550	4170	405	370	0·98	33	69	53
655	6320	420	380	0·83	46	80	64

TABLE XII.

Products obtained per short ton of different lignites from the Estevan Area, Carbonized at 575-600°C.

Results computed to a basis of coals containing 33 per cent water and 7 per cent ash.

Coal.	Carbonized residue.		Gas.		Ammonium sulphate.	Tar oils. imperial.	Available binder.
	Weight.	Calorific value.	Volume.	Calorific value.			
	lbs.	B. Th. U. per lb.	cub. ft.	B.Th.U. per cub.ft	lbs.	gallons.	%
A	870	12800	3260	415	11·1	6·9	3·6
B	866	12700	3340	410	11·8	6·4	2·9
C	874	12700	3320	380	11·1	4·2	2·2
D	879	12750	3310	410	12·0	4·9	2·1
E	880	12600	3210	385	11·6	5·0	2·3
El	851	11010	3230	300	11·2	3·4	....

NOTE.—The above figures were calculated from experimental results on coals with varying water and ash contents. Sample El was outcrop coal.

V.

REPORT OF MECHANICAL WORK AT FUEL TESTING STATION.

B. F. HAANEL, ESQ.,

Chief of Fuels and Fuel Testing Division.

Dear Sir,—I herewith submit Summary Report for Fiscal year ending March 31, 1919, of the Mechanical Division of the Mines Branch, Department of Mines.

Special attention is drawn to the number of experimental machines and apparatus for the different divisions, most noteworthy being that of the Fuel Testing Division for which the following machines and apparatus were designed and constructed: a rotary retort to be used in connexion with lignite investigation; two new wood turning lathes not yet completed; three double door aluminium desiccators nearing completion; and three special mercury winches to be used in connexion with mine air investigation.

There has also been a number of special pieces of apparatus designed and constructed in connexion with the experimental work of the Fuel Testing Division and the Ore Dressing Laboratories, which have demanded considerable time in designing and making, as such apparatus, being impossible to purchase, presents problems which are not met with in routine work.

Miscellaneous small jobs in connexion with the experimental work of the other Divisions of the Mines Branch were also designed and completed by our mechanical staff, either in the machine shops at the Fuel Testing Station, or at the Sussex Street building.

All of which is respectfully submitted.

(Signed) A. W. Mantle,
Mechanical Superintendent.

SUMMARY COST STATEMENT OF LABOUR COMPLETED, AND MATERIAL USED, DURING THE FISCAL YEAR ENDING MARCH 31, 1919.

	Labour.	Material.
Ore Dressing Division	$2,200 63	$1,012 10
Chemistry Division	1,145 86	520 78
Fuel Testing Division	801 95	85 68
General, Mines Branch	356 96	49 40
Ceramic Division	84 09	15 62
Non-metals Division	267 84	35 02
Metalliferous Division	10 77	0 32
Total	$4,868 10	$1,718 92

ORE DRESSING AND METALLURGICAL DIVISION.

I.

REPORT OF PROGRESS.

G. C. MACKENZIE, *Chief of Division.*

While the writer gave general supervision to the work of this Division, he devoted the most of his time to his secretarial duties in connexion with the Canadian Munition Resources Commission, and left the actual operation of the ore testing laboratories to his first assistant engineer, Mr. W. B. Timm.

Mr. C. S. Parsons resigned his position as second assistant engineer in May, and the vacancy thus created remained unfilled to the end of the calendar year.

The Division continued to act as samplers and assayers for the Imperial Munitions Board as explained in the last Summary Report, but as the Board purchased very little molybdenite or ferro-molybdenum after January 1, 1918, this work was much lighter than it had been during the previous year.

The practice of milling molybdenite ores on a custom basis was discontinued after the 1st of August, principally because the urgent demand for this mineral by the British Government has ceased and also on account of the interference such commercial work caused with the routine testing work of the laboratories. The concentration of several large bulk samples of molybdenite ore was, however, undertaken on the basis of test work.

PRODUCTION OF MOLYBDENITE CONCENTRATES.

DEPARTMENT OF MINES, ORE DRESSING LABORATORIES, OTTAWA, CANADA.

For year ending December 31, 1918.

Shipper.	Locality.	Crude Ore Received.	MoS_2.	Content MoS_2.	Recovery.	MoS_2 Recovered
		Lbs.	p.c.	Lbs.	p.c.	Lbs.
*Barton, Jas. W	Nett Lake, near Timagami Station, T. & N.O. Ry.	1,212·0	8·42	102·05		
*Bertram, H. A.	Tippings Farm, south half lots 4 & 5, Clarendon Tp., Pontiac Co., Que.	19,582·0	·27	52·57		
Bancroft Mining Co.	Bancroft, Ont.	694·5	4·19	29·10		
*Burchill, H. C.	New Ross, Lunenburg Co., N.S.	40,684·0	·49	198·132		
Cole, J. E	Sunset Mine, Dacre, Ont.	39,561·5	2·64	1042 77		
Day, James F	Near Haley's Station, Renfrew Co., Ont.	2,579·0	1·97	50·80		
Dunright, John	Leminster, Hants Co., N.S.	376·0	1·08	4·06		
International Molybdenum Company.	Lots 16 & 17, Con. xi. Brougham Tp. Renfrew Co., Ont..	89,349·0	1·84	1509·483		
Lillico, R. J	Lots 14&15, Con. xii. Monmouth Tp., Haliburton Co., Ont.	203,996·5	·533	1088·35		
*New Hazelton Gold-Cobalt Mines Ltd.	New Hazelton, B.C.	53,228·0	1·40	745·19	86·7	12,819·056
Ryan, W. J	Timothy Mountain, 25 miles N.E. from Lac La Hache, close to 25° parallel, Lilloet Division, Northern Division, B.C.	761·0	29·99	228·23		
Schreiner, J. C	Ashdod, Ont	37,928·0	0·45	170·68		
Spain, W. J	Lots 31 & 32, Con. v., Lot 31, Con. iv. Griffith Tp., Renfrew Co., Ont.	66,390·0	2·10	1394·19		
*Standard Molybdenite Co.	Maniwaki, Que	24,985·0	0·40	107·085		
Taylor, A. W	Ashdod, Ont	118,722·5	5·68	6760·58		
Williams & Ruffner..	Rossland, B.C	5,426·0	14·63	793 02		
Wood, O. E. & Company.	Squaw Lake, Que	692·0	71·85	497·081		

17 Shippers shipped 706,167 lbs Crude Ore at 2·09 p.c. containing 14,773·37 lbs MoS_2.

NOTE.—The shipments marked with * are experimental tests.

II.

ORES TESTED AND REPORTS THEREON.

W. B. Timm, *Assistant Engineer;* C. S. Parsons, *Assistant Engineer.*

The following ores have been tested and reports made thereon during the calendar year. 1918:—

No. of Test.	Ore or Rock.	Locality.	Shipper.	Weight. Ton	Lb.
75	Titaniferous iron ore.....	St. Urban, Que..........	Titanic Iron Co., Quebec, Que......	1 car	load.
76	Molybdenite ore........	New Ross, N.S.........	H. C. Burchell, Windsor, N.S.....	20	
77	"	Kakabeka Falls, Ont....	F. R. Aufhammer..	....	270
78	Copper ore........ . .	Ikeda Bay, B.C.........	A. Ikeda, Ikeda Bay, B.C..........	....	350
79	Manganese ore..........	Walton, Hants Co., N.S.	Canadian Munition Resources Commission	22	
80	Molybdenite ore	Alice Arm, B.C.........	International Molybdenum Co., Renfrew, Ont..	...	1,145
81	"	Rossland, B.C..........	Williams & Ruffner, Rossland, B.C.	1	1,520
82	"	Nett Lake, Ont.........	Jas. W. Barton, Toronto, Ont	...	1,230
83	Molybdenite Gold-Cobalt ore..................	New Hazelton, B.C....	New Hazelton Gold-Cobalt Mines, Ltd	....	870
84	Zinc-lead ore............	Carmacks, Y.T.........	Dr. A. W. G. Wilson, Mines Branch.	...	3
85	Graphite............... .	Buckingham, Que... ...	New Quebec Graphite Co., Ltd., Buckingham, Que.................	...	200
86	Molybdenite............	Haley's Station, Ont....	J. F. Day, Sudbury, Ont...........	1	601
87	Gold ore	Lake Aylmer, Que ...	Chas. J. Wallich, Detroit, Mich....	....	238
88	Pyrites	English, Ont...	Robt. Gamble, Ottawa, Ont........	...	460
89	Gold ore..	Sudbury, Ont.	J. S. Black, Sudbury, Ont....	.. .	220
90	Tungsten ore......	Dublin Gulch, Y.T......	Frank Cantin, Dublin Gulch, Y.T..	....	354
91	Molybdenite....	Hull, Que...............	Canadian Wood Molybdenite Co., Ottawa, Ont	29	
92	"	Loon Lake, Ont.	J. A. Johnston, Loon Lake, Ont....	....	502
93	"	Campbell's Bay, Que....	H. Leger, Campbell's Bay, Que.....	....	759
94	Manganese.............	Bathurst, N.B	W. F. C. Parsons, Bathurst, N.B	...	10
95	Ferro-molybdenum slag..	Belleville, Ont.........	Tivani Electric Steel Co., Belleville, Ont..	38	
96	Manganese............	Gowland Mountain, N.B.	Dr. Hays, Geological Survey........	...	10
97	Molybdenite.......	Hull, Que.	Wood Molybdenite Co., Ottawa, Ont.............................	....	150
98	Titaniferous iron ore.....	. . ..	Dr. W. L. Goodwin, Kingston, Ont.	. .	275
99	Molybdenite..	Masham, Que..........	Wood Molybdenite Co., Ottawa, Ont....	1	85
100	Manganese.............	Bathurst, N.B	O. Turgeon, Bathurst, N.B..	...	25
101	Tungsten......	Eureka, N.S....	Geo. A. Cameron, Eureka, N.S...	....	1,067
102	Graphite..	Lachute..	Thos. H. Rae, Lachute, Que........	....	300
103	"	....	Jas. H. Mason, Toronto, Ont.....	....	50
104	Tungsten	Yukon Territories. ...	D. E. Clindinin, Dawson, Y.T.....	....	1,293

Test No. 75.

A carload of titanic iron ore, "ilmenite," from St. Urbain, Quebec, was received from the Titanic Iron Co., Quebec city.

A 50-pound sample was picked from the carload and crushed to 50 mesh. This sample gave an analysis of:—

Fe..	37·62 per cent.
TiO_2..	40·49 "

It was run through the Ullrich magnetic separator with the rings raised three-fourths inch from the feed plate and with a magnetic field of 4 amperes, 110 volts, giving the following products:—

Magnetic—		
Weight	4·0	pounds.
Analysis—Fe	38·81	per cent.
TiO_2	39·88	"
Non-magnetic—		
Weight	44·0	pounds.
Analysis—Fe	37·52	per cent.
TiO_2	40·70	"

A larger sample was crushed to 35 mesh, ·0164-inch aperture, and run through the separator with the rings stepped, the outer ring three-fourths inch from feed plate, second ring five-eighths inch, third ring one-half inch, and inner ring three-eighths inch. The product from each ring was weighed and sampled separately. A magnetic field of 10 amperes, 110 volts, was carried on the machine. The weights and analyses of the products are given in the following table:—

Product.	Weight.	Analysis.	
		% Fe.	% TiO_2.
	Lbs.		
Ring No. 1	0·75	38·62	36·63
" 2	0·50	42·05	33·18
" 3	27·50	39·63	41·55
" 4	304·50	39·63	41·55
Middling	34·00	37·51	38·55
Tailing	96·50	34·57	35·66

Conclusions.—From the above results it will be seen that a separation of the iron and titanium cannot be made by any mechanical means of ore dressing. The ore is an ilmenite, the titanium being chemically combined with the iron so that in raising the iron content the titanium content is also raised and vice versa.

Test No. 76.

NEW ROSS MOLYBDENITE ORE.

A carload of molybdenite ore was received on March 27 from H. C. Burchell, Windsor, N.S. This carload contained 122 barrels in two lots, marked X and XX, taken from two different points on the property, and in both cases the ore was supposed to be the run-of-mine.

Lot X	40	barrels.
Gross weight	15,048	pounds.
Net weight	13,854	"
Moisture	0·96	per cent.
Dry weight	13,721	pounds.
Analysis—MoS_2	0·54	per cent.
MoO_3	trace.	
Cu	0·08	per cent.
Content—MoS_2	74·0934	pounds.
Lot XX	82	barrels.
Gross weight	29,762	pounds.
Net weight	27,260	"
Moisture	1·09	per cent.
Dry weight	26,963	pounds.
Analysis—MoS_2	0·46	per cent.
MoO_3	trace.	
Cu	0·08	per cent.
Content—MoS_2	124·0298	pounds.

The ore consists of molybdenite of the flake variety in quartz with a small amount of the granite wall rock. A very small amount of iron and copper sulphides, and mica is present.

Preliminary Test.

Several of the barrels were opened and some pieces of the ore were taken from each to make up a sample for a small test on the laboratory Callow testing machine.

This sample was first crushed to 20 mesh and a sample taken for analysis. The remaining portion was cut into two lots; one was crushed to 30 mesh and the other to 40 mesh.

The analysis of this sample showed it to contain:—

MoS_2—0·36 per cent.

Test No. i—30-mesh material.

Ore..	1,000 grams.
Oil..	Pine oil ½ pound to ton of ore.
	Coal oil ¼ pound to ton of ore.

Mixed in small pebble jar for 10 minutes before adding to the machine.

Only the tailing from this test was analysed.

This gave MoS_2—0.04 per cent.

Test No. ii—40-mesh material.

Ore..	1,000 grams.
Oil..	Pine oil ½ pound to ton of ore.
	Coal oil ¼ pound to ton of ore.

Mixed in small pebble jar for 10 minutes before adding to the machine.

Concentrate obtained..	3·1 grams.
MoS_2..	63·45 per cent.
Content..	1·967 grams.
Recovery..	71 per cent.
Milling obtained..	32 grams.
MoS_2..	1·91 per cent.
MoS_2..	0·611 grams.
Percentage of MoS_2 values..	22 per cent.
Tailing obtained..	964·9 grams.
MoS_2..	0·02 per cent.
Content..	0·193 grams.
Loss..	7 per cent.

Figuring on a recovery of 70 per cent of the MoS_2 values in the middling, this would give a total recovery of the molybdenite values in the crude ore of 80 per cent.

Large Scale Test.

The method of crushing and concentration adopted on the carload lot was as follows:—

The ore was first crushed in the jaw crusher with the jaws set at 1″ opening, and the crushed ore fed by a push feeder which delivered it to an elevator which discharged into a Vezin sampler where one-tenth of the ore stream was cut out, the main flow travelling down a chute to the Hardinge ball mill. Here the oil was fed so as to become thoroughly emulsified in the mill. From the ball mill, the pulp flowed down a launder to a 3″ centrifugal pump which delivered it on to a Callow screen. The screen used was a 35-mesh ton-cap screen. The oversize from the screen was returned to the mill, the undersize went direct to the Callow rougher cell. This method was changed during the run due to trouble encountered by the presence of foreign oils which would get into the circuit at times and kill the froth on the cells. This oil presumably came from the ore. The undersize from the screen flowed into a Callow cone tank where a slight washing action was given the pulp. From the cone tank the thickened pulp was drawn to an elevator and the elevator discharged into a launder where the density of the pulp was regulated by the addition of water, and this launder delivered it to the Callow rougher cell. In this case the coal oil was added to the ball mill, the pine oil to the boot of the elevator. The tailings from the rougher cell were pumped to the waste dump after being sampled. The rougher concentrates were reconcentrated in the cleaner cell.

Both lots were sampled separately but the concentrates were allowed to collect together.

The tailing analysis of lot X was 0·17 per cent MoS_2, giving a recovery on this lot of 68·7 per cent.

The tailing analysis of lot XX was 0·15 per cent MoS_2, giving a recovery on this lot of 67·5 per cent.

185 pounds of concentrates were obtained from the whole shipment with an analysis of 72·75 per cent MoS_2.

Conclusions.—The ore is an ideal one, since it is easily crushed and easily concentrated. The results obtained from the small preliminary test are more in accord with what could be obtained in actual practice than the large test, due to our trouble with foreign oil in the circuit. On an ore of this class of a grade 0·5 per cent MoS_2 a recovery of the molybdenite values of 85—90 per cent should be looked for, while with the cells working properly, a concentrate of 85 per cent MoS_2 grade should be obtained.

Test No. 77.

MOLYBDENITE ORE FROM KAKABEKA FALLS.

A sample of 270 pounds of molybdenite ore was received on March 27, 1918, from F. R. Aufhammer. This ore was supposed to represent the run-of-mine from a molybdenite property at Kakabeka Falls, Ont.

The molybdenite is of the amorphous variety in a quartz gangue. A small amount of iron and copper sulphides is present.

The sample was crushed to 10 mesh. It was cut down in a Jones sampler and a portion crushed to pass 80 mesh and another portion to pass 100 mesh. Both the 80-mesh and 100-mesh samples were analysed.

80-mesh material—	
MoS_2	1·29 per cent.
Cu	0·05 "
Bi	absent.
As	trace.
100-mesh material—	
MoS_2	1·25 per cent.
Cu	0·04 "
Bi	absent.
As	trace.

A series of small laboratory tests were made on the Callow machine.

Test No. i—80-mesh material.

Ore	1,000 grams.
Oil mixture	Pine oil—½ pound to ton of ore.
	Coal oil—1 pound to ton of ore.

Mixed in small pebble jar for 10 minutes before adding to the machine.

Concentrate	23·2 grams.
MoS_2	33·65 per cent.
Content	7·8068 grams.
Recovery	69·0 per cent.
Middling	60·4 grams.
MoS_2	2·63 per cent.
Content	1·58852 grams.
Percentage MoS_2 values	14·0 per cent.
Tailing	916·4 grams.
MoS_2	0·21 per cent.
Content	1·9236 grams.
Loss	17·0 per cent.

Figuring on a recovery of 70 per cent of the molybdenite values in the middling, the above test would show a recovery of 79 per cent of the molybdenite values in the ore.

Test No. ii—80-mesh material.

Ore	1,000 grams.
Oil mixture	Pine oil—½ pound to ton of ore. Hardwood creosote—¼ pound to ton of ore. Coal oil—2 pounds to ton of ore.

Mixed in pebble jar for 10 minutes before adding to the machine.

Concentrate	16·5 grams.
MoS_2	33·65 per cent.
Content	5·55225 grams.
Recovery	53·8 per cent.

NOTE.—This concentrate was obtained by screening the original concentrate from the machine on a 100-mesh screen.

1st middling	8·7 grams.
MoS_2	21·83 per cent.
Content	1·89921 grams.
Percentage MoS_2 values	18·4 per cent.

NOTE.—This middling was obtained by screening the original concentrate on 100-mesh screen.

2nd middling	151·3 grams.
MoS_2	1·09 per cent.
Content	1·64917 grams.
Percentage MoS_2 values	16·0 per cent.
Tailing	823·5 grams.
MoS_2	0·15 per cent.
Content	1·23525 grams.
Loss	11·8 per cent.

Figuring on a recovery of 70 per cent of the MoS_2 values in the middling, the above test would show a recovery of 83·4 per cent of the molybdenite values in the ore.

Test No. iii—100-mesh material.

Ore	1,000 grams.
Oil mixture	Pine oil—½ pound per ton of ore. Coal oil—1 " " "

Mixed in pebble jar for 10 minutes before adding to the machine.

Concentrate	24·5 grams.
MoS_2	27·20 per cent.
Content	6·664 grams.
Recovery	61·6 per cent.
Middling	103·8 grams.
MoS_2	2·09 per cent.
Content	2·16942 grams.
Percentage MoS_2 values	20·0 per cent.
Tailing	871·7 grams.
MoS_2	0·23 per cent.
Content	2·0049 grams.
Loss	18·4 per cent.

Figuring on a recovery of 70 per cent of the MoS_2 values in the middling, the above test would show a total recovery of 75·6 per cent of the molybdenite values in the ore.

Test No. iv.—A portion of the 100-mesh material was ground to pass 150 mesh.

Ore	1,000 grams.
Oil mixture	Pine oil—½ pound per ton of ore. creosote—¼ pound per ton of ore. Coal oil—2 pounds per ton of ore.
Concentrate	3·75 grams.
MoS_2	49·95 per cent.
Content	1·873 grams.
Recovery	18·0 per cent.

NOTE.—This concentrate was obtained by screening original concentrate on 100-mesh screen.

1st middling	5·0 grams.
MoS_2	30·53 per cent.
Content	1·5265 grams.
Percentage MoS_2 values	14·7 per cent.

NOTE.—This middling was obtained by screening original concentrate on 100-mesh screen.

2nd middling	52·25 grams.
MoS_2	5·33 per cent.
Content	2·7849 grams.
Percentage MoS_2 values	26·7 per cent.
Tailing	939 grams.
MoS_2	0·45 per cent.
Content	4·2255 grams.
Loss	40·6 per cent.

Figuring on a recovery of 70 per cent of the MoS_2 values in the middling, the above test would show a total recovery of 51·4 per cent of the molybdenite values in the ore.

Conclusions.—From former tests on this ore it was proven that it should be crushed to 80 mesh to obtain a low tailing and the above tests prove that no better tailing can be obtained by finer crushing.

The concentrates on examination show that the molybdenite is not all freed from the gangue at 80 mesh, hence a low grade concentrate will be obtained.

The better method of procedure with this class of ore would be to grind to 80 mesh to secure a low tailing; regrind the concentrates, and reconcentrate them to obtain a high grade molybdenite product.

Test No. 78.

COPPER ORE FROM IKEDA BAY, B.C.

A shipment of 5 bags, 350 pounds of the ore, was received on September 5, 1917, from Mr. A. Ikeda, Ikeda bay, B.C.

The ore consisted of chalcopyrite in heavy dark gangue, associated with iron pyrites and magnetite. The ore contained silver and gold values.

An analysis of the sample was as follows:—

Copper	1·18 per cent.
Silver	1·36 oz. per ton.
Gold	0·04 " "

Oil flotation was the method of treatment adopted.

Test No. i.—The ore was crushed to pass 50 mesh and concentrated in a set of laboratory size Callow cells. The test resulted in obtaining a concentrate running 11·46 per cent copper with a recovery of 86·00 per cent of the copper values assuming that it would be possible to recover 70 per cent of the content of the middling.

The oil used in this test was a mixture containing 10 per cent coal tar, 50 per cent coal tar creosote and 40 per cent heavy hardwood creosote oil. The amount used was approximately 1·5 lbs. per ton. The condition of the pulp was neutral.

Test No. ii.—The sample was crushed to pass 80 mesh and floated as in test No. i. A concentrate was obtained running 11·00 per cent copper with a recovery of 90 per cent, assuming as in test No. i that 70 per cent of the content of the middling is recoverable.

Test No. iii.—The sample was crushed to pass 100 mesh and floated as in the two previous tests.

This test resulted in a concentrate containing 7·55 per cent of copper and 0·25 oz. of gold, with a recovery of 87·2 per cent of the copper and 95·5 per cent of the gold, assuming as before that 70 per cent of the content of the middling is recoverable.

Test No. iv.—This sample was crushed to pass 80 mesh and treated under the same conditions as in test No. iii. A concentrate was obtained analysing 8·75 per cent copper and 0·30 oz. of gold with a recovery of 92 per cent of the copper and 77·0 per cent of the gold.

Conclusions.—The results obtained in the above tests are tabulated in table No. I. The assumption that 70 per cent of the values in the middling is recoverable is fair and if anything a low estimate. In practice, the middling would naturally be returned to the flotation circuit, or in some cases to the crushing circuit after dewatering.

These tests show a remarkably high extraction of both the copper and gold values and there is no doubt that in actual practice a higher grade concentrate could be obtained with a similar extraction.

The tests would also indicate that the ore should be crushed to around 80 mesh in order to obtain a high recovery of the gold but it is possible that large scale operation may prove that a coarser product can be successfully treated.

TABLE No. I.

Test No.	Mesh.	Heads.			Concentrates.			Middlings.			Tailings.			Extraction assuming 70 % recovery of content of middling.	
		Grams Wt.	Copper P.C.	Au oz.	Grams Wt.	Copper P.C.	Au oz.	Grams Wt.	Copper P.C.	Au oz.	Grams Wt.	Copper P.C.	Au oz.	Copper	Gold
i	50	1000	1·0	0·0!	72	11 50	....	82·5	0·76	....	845·5	0·15	....	86	
ii	80	1000	1·0	0·04	80	11·00	..	116·0	0·30	...	804·0	0·12	....	90	
iii	100	1000	1·0	0·04	104	7·50	0·25	204·0	0·65	0·06	692·0	0.12	trace.	87·0	95·5
iv	80	1000	1·0	0·037	90	8·70	0·30	90·0	1·00	0·02	820·0	0·17	0·01	92·0	77·0

Test No. 79.

HANTS COUNTY, N.S. MANGANESE ORE.

A shipment of 160 barrels of manganese ore was received December 24, 1917, from the property of E. Chisholm, Walton, Hants Co., N.S. This shipment was submitted through the Munition Resources Commission, Ottawa, Ont.

The ore was pyrolusite and manganite in sandstone, some of which was fairly coarsely crystalline, freeing at about 30 mesh, gradually grading to finely crystalline and disseminated through the sandstone.

Net weight of ore received	47,045·5 pounds.
Moisture	4·88 per cent.
Dry weight of ore received	44,749·5 pounds.
Analysis—Mn	12·90 per cent.
Fe	5·11 "
SiO_2	69·09 "
P	0·017 "
Content — Mn	2,772·68 pounds.
Fe	22,286·76 "

The products desired were a commercial manganese concentrate; a chemical product, high in manganese (over 50 per cent), low in iron and silica; and a metallurgical product suitable for conversion into ferro-manganese in the blast or electric furnace.

The method of investigation adopted was one of careful crushing and sizing and the concentration of the sized material to determine to what point crushing would have to be carried to obtain a high grade concentrate and what further treatment would be necessary to recover the manganese values.

The ore was crushed in a jaw crusher set at 1-inch opening, elevated to ore bins and fed by a push feeder to a set of rolls set at ½-inch opening. From the rolls the ore passed through a Vezin sampler where one-tenth of the feed was cut out, thence to a dryer and to storage bins. From the storage bins the ore passed to a Traylor ball mill crushing to 18 mesh; from the ball mill to a Keedy sizer where five sizes were made. Each size was run over a concentrating table and the product re-treated where necessary.

WEIGHTS AND ANALYSES OF SIZED ORE.

Size.	Dry Weight.	Analysis.		Content.	
	Lbs.	% Mn.	% Fe.	Lbs. Mn.	Lbs. Fe.
+ 28	2,578·5	16·16	7·78	416·6856	200·6073
− 28 + 42	1,839·0	15·34	6·80	282·1026	125·0520
− 42 + 62	6,700·0	12·87	6·19	862·2900	414·7300
− 62 + 86	8,896·0	10·36	4·07	921·6256	362·0672
− 86	24,736·0	13·26	4·64	3,279·9936	1,147·7504
Totals and averages...	44,749·5	12·88	5·03	5,762·6974	2,250·2069

FIRST CONCENTRATION.

Size.	Dry Wt.	Analysis.					Content.	
	Lbs.	% Mn.	% Fe.	% SiO_2	% P.	% S.	Lbs. Mn.	Lbs. Fe.
+ 28	275·0	39·34	6·62	26·78	......	......	108·1850	18·2050
− 28 + 42	488·0	34·66	7·20	32·58	......	......	169·1408	35·1360
− 42 + 62	412·0	38·85	4·80	27·66	......	......	160·0620	19·7760
− 62 + 86	363·0	51·68	4·41	9·35	·172	·385	187·5984	16·0083
	111·0	45·90	6·18	14·66	......	......	50·9490	6·8598
− 86	465·0	51·80	4·14	9·45	·232	·635	240·8700	19·2510
	1,471·0	45·02	6·86	13·41	·037	·033	662·2442	100·9106
Totals and averages..........	3,585·0	44·04	66·03				1,579·0494	216·1467

On sizes + 28, − 28 + 42 and − 42 + 62 a concentrate and middling were made, both of which were reground and re-treated as the pyrolusite was not freed.

On sizes − 62 + 86 and − 86, a final concentrate practically pure pyrolusite, a second concentrate lower grade of pyrolusite and manganite, a middling to be re-treated and a tailing were made.

The total middlings from the first concentration were reground to 60 mesh (this mesh corresponding closely to Tyler standard) in a ball mill and reconcentrated. A concentrate, a middling held and a tailing to waste were made.

The first concentrate made from sizes + 28, − 28 + 42, and − 42 + 62 was reground to 35 mesh (Tyler's standard) and reconcentrated. A concentrate, a middling held and a tailing to waste were made.

The following tables give the results obtained from the treatment of this shipment of ore:—

Table showing Weights and Analyses of Concentration Products.

Size.	Weights and Analyses of Sized Ore. Dry Wt.	Analysis. Mn.	Analysis. Fe.	Content. Mn.	Content. Fe.	Concentrates Made. Dry Wt.	Analysis. Mn.	Analysis. Fe.	Content. Mn.	Content. Fe.
	Lbs.	%	%	Lbs.	Lbs.	Lbs.	%	%	Lbs.	Lbs.
+28	2578·5	16·16	7·78	416·6856	200·6073	275·0	39·34	6·62	108·1850	18·2050
−28+42	1839·0	15·34	6·80	282·1026	125·0520	488·0	34·66	7·20	169·1408	35·1360
−42+62	6700·0	12·87	6·19	862·2900	414·7300	412·0	38·85	4·80	160·0620	19·7760
−62+86	8896·0	10·36	4·07	921·6256	362·0672	363·0	51·68	4·41	187·5984	16·0083
						111·0	45·90	6·18	50·9490	6·8598
−86	24736·0	13·26	4·64	3279·9936	1147·7504	465·0	51·80	4·14	240·8700	19·2510
						1471·0	45·02	6·86	662·2442	100·9106
Totals and Averages	44749·5	12·88	5·03	5762·6974	2250·2069	3585·0	44·046	6·03	1579·0494	216·1467
Re-treatment of Middlings	20048·0	11·44	5·30	2293·4912	1062·5440	1480·0	36·01	13·20	532·9480	195·360
Re-treatment of 1st Concentrates	1175·0	37·22	6·22	437·3878	73·1170	935·0	38·95	6·40	364·1830	59·840

NOTE.—The above meshes referred to are a special mesh size used for screening and do not correspond to any standard.

Middlings Made—Held for Re-treatment. Dry Wt.	Analysis. Mn.	Analysis. Fe.	Content. Mn.	Content. Fe.	Tailings to Waste. Dry Wt.	Analysis. Mn.	Analysis. Fe.	Content. Mn.	Content. Fe.	Slime and Handling Loss. Dry Wt.	Analysis. Mn.	Analysis. Fe.	Content. Mn.	Content. Fe.
Lbs.	%	%	Lbs.	Lbs.	Lbs.	%	%	Lbs.	Lbs.	Lbs.	%	%	Lbs.	Lbs.
2303·5	15·39	7·92	308·5006	182·4023	No	Tailings	Made.							
1351·0	8·36	6·656	112·9618	89·9160	No	Tailings	Made.							
6288·0	11·168	6·28	702·2280	394·9540	No	Tailings	Made.			5584·0	20·08	7·58	1121·2980	423·2189
10105·5	11·576	3·91	1169·8008	395·2717	15532·5	4·95	3·53	768·8588	548·2973					
20048·0	11·44	5·30	2293·4912	1062·5410	15532·5	4·95	3·53	768·8588	548·2973	5584·0	20·08	7·58	1121·2980	423·2189
145·0	19·48	9·80	28·246	14·210	12506·0	5·25	3·75	656·565	468·975	5917·0	18·18	6·49	1075·7322	383·999
140·0	16·50	6·42	23·10	8·988	No	Tailings	Made.			100·0	50·11	4·29	50·1058	4·289

Summary and Tabulation of Final Products.

Final Concentrates										Middlings Held	Tailings to Waste	Slime and Handling Loss.
Dry Wt. Lbs.	Analysis							Content Lbs. Mn	Recovery of Mn values			
	% Mn	% Fe	% SiO_2	% P	% S	% CaO	% MgO					
465	51·80	4·14	9·45	0·232	0·635	....	.....	240·8700	4·18	Dry Wt. 285 Lb.. Analysis— Mn—18·02 %... Fe— 8·14 %... Content— Mn— 51·346 Lb...... Percentage Mn values— 0·89 %.........	Dry Wt. 28038·5 Lb...... Analysis— Mn—5·08. ..... Fe— 3·63.. .... Content— Mn— 1425·4288 Lb... Loss Mn values— 24·74 %	Dry Wt. 11601 Lb. Analysis— Mn—19·37 %. Fe— 6·995 %. Content— Mn— 2247·1355 Lb. Loss Mn values— 38·99 %.
263	51·68	4·41	9·35	0·172	0·385	....	....	187·5984	3·26			
111	45·90	6·18	14·66	....	....	....	.... ..	50·9490	0·88			
1471	45·02	6·86	13·41	0·037	0·033	....	....	662·2442	11·49			
935	38·95	6·40	....	... .	....	......	....	364·1830	6·32			
1480	36·01	13·20	21·03	....	... .	. ....	....	532·9480	9·25			
4825	42·251	....	....	....	....	....	.. ..	2038·7926	35·38			

Conclusions.—From the above tables, it has been proven that it is necessary to crush the ore to about 40 mesh of the ordinary screen scale in order to free it and effect any kind of concentration. Crushing to this mesh, 10 to 12 per cent of the manganese values should be obtained of a grade 50 per cent Mn.

It will then be necessary to pass both the middling and tailing separately over a second set of tables where a concentrate and middling will be made in one case and a concentrate, middling and tailing in the other case. The concentrate made in both cases should be of a grade 45 per cent Mn., and represent a recovery of from 20 to 25 per cent of the manganese values in the crude ore; the middling would be re-treated and the tailing discarded.

The middling from this second concentration will have to be reground to from 60 to 80 mesh (ordinary screen scale) and reconcentrated. The middling from this third concentration should go over a second set of tables before returning to the regrinding circuit and the tailings from both sets of tables discarded. A concentrate of a grade 40 per cent Mn., with a recovery of 20 per cent of the manganese values in the crude should be obtained.

By the method of treatment outlined above it is possible to make commercial products on this ore and that it should be possible to make a recovery of between 50 and 60 per cent of the manganese values in the ore.

In the treatment of this ore at the testing laboratories the products had to be handled so often and in such a manner that the handling and slime loss was very high. With a proper installation, the handling loss would be nil and the slime loss eliminated to a large extent. From the above tables it will be noted that the actual loss in tailings sent to the waste dump contained 24·74 per cent of the manganese values in crude ore with an analysis of 5·08 per cent Mn. Allowing for a slime loss of 20 per cent of the Mn values in the crude ore the recovery would be 55 per cent.

Test No. 80.

ALICE ARM MOLYBDENITE ORE.

Supplementing our report of June 13, 1917, in which are contained the results of our small laboratory tests on Alice Arm molybdenite ore we made a regular mill test on this shipment with the following results:—

Net weight of ore treated	1,145 pounds.
Analysis—MoS_2	1·67 per cent.
MoO_3	0·07 "
Cu	0·17 "
Content —MoS_2	19·1215 pounds.
Cu	0·19465 "

The ore was ground in the ball mill to 60 mesh. (A 60-mesh ton-cap screen used.)

Rate of feed	1 ton per hour.
Oil mixture	Coal oil—½ pound per ton of ore.
	Pine oil—⅓ pound per ton of ore.

A sample of the concentrates and tailings was taken every 10 minutes.

Concentrate	36 pounds.
Analysis—MoS_2	44·50 per cent.
Cu	0·125 "
Content —MoS_2	16·020 pounds.
Cu	0·045 "
Recovery—MoS_2 values	83·7 per cent.
Cu	23·1 "
Tailing	1,109 pounds.
Analysis—MoS_2	0·29 per cent.
Cu	0·013 "
Content —MoS_2	3·2161 pounds
Cu	0·14965 "
Loss—MoS_2 values	16·8 per cent.
Cu values	76·9 "

Conclusions.—No trouble was experienced in the operation of the cells on this crude ore. An ideal froth was obtained on both rougher and cleaner cells, showing that the trouble experienced in our runs on two shipments of ground ore from the International Molybdenum Co., Renfrew, Ont., supposed to be for the most part of this ore, was not due to the nature of the ore itself, but rather to the fact of it being ground and allowed to stand and oxidize for a considerable time.

In the above test the grade of the concentrate is low and does not represent what could be secured in practice, as the cells were run so long to clean them up that the other sulphides were floated as well as the molybdenite. Owing to the nature of the ore however it does not seem probable that a grade much above 70 per cent MoS_2 would be made unless by regrinding the concentrate and refloating. By raising the grade of the concentrate the copper values would be reduced.

The tailings looked very clean as far as free flakes was concerned. It is doubtful whether any better tailing could be obtained, unless a little finer crushing was adopted.

Test No. 81.

MOLYBDENITE ORE FROM WILLIAMS AND RUFFNER, ROSSLAND, B.C.

A shipment of thirty-four bags of molybdenite ore was received on April 9 from Williams and Ruffner, Rossland, B.C.

The ore was high grade, of the flake variety, in quartz, with a small amount of iron and arsenical pyrites.

Gross weight of sample received	3,520 pounds.
Net weight of sample received	3,503 "
Moisture	2·28 per cent.
Net dry weight	3,423 pounds.
Analysis—MoS_2	10·54 per cent.
MoO_3	0·52 "
Pt	nil.
Au	trace.
Ag	trace.
Content—MoS_2	360·7842 pounds.
MoO_3	17·7996 "

A small scale test was first run on the laboratory Callow flotation machine. The moisture sample of the ore was crushed to pass 50 mesh; 1,000 grams were taken and mixed in a pebble jar for ten minutes with oil mixture—pine oil, ½ pound to ton of ore, hardwood creosote, ¼ pound to ton of ore, and coal oil, 5 pounds to ton of ore. A little water was added. It was then added to the machine, from which the following products were obtained:—

Concentrate	158 grams.
Analysis	65·97 per cent MoS_2
Content	104·2326 grams MoS_2
Recovery	87·6 per cent.
Middling	136 grams.
Analysis	4·30 per cent MoS_2
Content	5·848 grams MoS_2
Percentage of MoS_2 values	4·9 per cent.
Tailing	706 grams.
Analysis	1·27 per cent MoS_2
Content	8·9662 grams MoS_2
Loss	7·5 per cent.

Figuring on a recovery of 70 per cent of the MoS_2 values in the middling, the total recovery would be 91 per cent of the molybdenum values in the ore. As this ore contains 0·52 per cent MoO_3 which would report in the tailings or lost in solution and not recoverable by flotation, the recovery of actual molybdenite values in the ore would be about 95 per cent.

Large Scale Test.—For the large scale test, the ore passed through the regular molybdenite circuit, namely, from the crusher to the ball mill, where the oil mixture was added and then to a Callow screen fitted with a 60-mesh ton-cap screen, the oversize returning to the mill, the undersize going direct to the flotation cells.

The following results were obtained:—

Concentrate	
Weight	487 pounds.
Analysis	70·85 per cent MoS_2
Content	345·0395 pounds MoS_2
Recovery	95·7 per cent.
Tailing	
Weight	2,936 pounds.
Analysis	0·53 per cent MoS_2
Content	15·5608 pounds MoS_2
Loss	4·3 per cent.

Conclusions.—The ore was found to be an ideal one for concentration by oil flotation. A high recovery was made, namely, 95·7 per cent. The grade of the concentrate was rather low, but this was due to having to continue the operation so long in order to clean up the flotation cells. In actual practice this would not occur and a higher grade concentrate would result.

Test No. 82.

NETT LAKE MOLYBDENITE ORE.

A shipment of 21 bags of molybdenite ore was received April 16, 1918, from Jas. W. Barton, Toronto, Ont.

This ore was obtained from a property at Nett lake, Ont., near the T. and N.O. railway and consisted of hand-cobbed ore.

The ore is of the flake variety, in quartz, associated with it is a small amount of iron and copper pyrites. A small amount of silver and gold values is present.

Gross weight received	1,230 pounds.
Tare	14 "
Net weight received	1,216 "
Moisture	0·322 per cent.
Dry net weight	1,212 pounds.
Analysis—MoS_2	8·42 per cent.
MoO_3	0·24 "
Cu	0·50 "
Ag	0·29 oz.
Au	0·03 "
Content — MoS_2	102·0504 pounds.

A grab sample of this ore was taken as it was being crushed and sampled for analysis.

This sample was crushed to 50 mesh for a test on the laboratory flotation machine. Flake representing 2 per cent MoS_2 was removed, being caught on the screen. A 1000 grams of the 50-mesh material was taken for a test.

Oil mixture added—½ pound pine oil per ton of ore.
¼ " hardwood creosote per ton.
5 pounds coal oil per ton of ore.

Concentrate obtained	55 grams.
Analysis—MoS_2	78·65 per cent.
Content—MoS_2	43·2575 grams.
Recovery	76·5 per cent.
First middling obtained	10·2 grams.
Analysis—MoS_2	57·15 per cent.
Content	5·8293 grams
Recovery	10·3 per cent.

This middling was obtained from the screening of the original concentrate on a 100-mesh screen.

Second middling obtained	101·6 grams.
Analysis—MoS_2	4·02 per cent.
Content	4·08432 grams.
Percentage MoS_2 values	7·2 per cent.
Tailing obtained	833·2 grams.
Analysis—MoS_2	0·41 per cent.
Content	3·41612 grams.
Loss	6·0 grams.

Figuring on a recovery of 70 per cent of the MoS_2 values in the middling, the total recovery would be 91·8 per cent of the molybdenum values in the ore. As this ore contains 0·24 per cent MoO_3 which would report in the tailings or lost in solution and not recoverable by flotation, the recovery of the actual molybdenite values in the ore would be about 95 per cent.

Large Scale Test.—For the large scale test the ore which was first crushed in the jaw crusher to 1 inch was fed into the ball mill, where the oil mixture was added and ground to pass a 60-mesh ton-cap screen, the oversize returning to the mill while the undersize went to the flotation cells.

The following results were obtained from the run of the ore:—

Concentrate	127 pounds.
Analysis	78·55 per cent MoS_2
Content	99·7585 pounds MoS_2
Recovery	97·8 per cent.
Tailing	1,085 pounds.
Analysis	0·19 per cent MoS_2
Content	2·0615 pounds MoS_2
Loss	2·2 per cent.

Conclusions.—This was found to be an ideal ore for concentration by oil flotation. Remarkable results were obtained for such a high grade ore. It is generally found that with such an ore all the molybdenite is not freed and a large portion of what is not freed is lost in the tailings. The gold and silver values in the ore are so small that their recovery would not be commercial. The grade of the concentrate made was rather low but this was due to the fact, that in order not to hold too much of the molybdenite values in the circuit, the operations were carried too far to obtain a cleaner concentrate.

Test No. 83.

MOLYBDENITE-GOLD ORE FROM NEW HAZELTON, B.C.

A shipment of 10 bags of molybdenite ore was received on November 21, 1917, from the New Hazelton Gold Cobalt Mines, Ltd., New Hazelton, B.C.

The ore consisted of molybdenite, in fine flakes approaching the amorphous variety; molybdite, the molybdenum oxide; sulphides of iron; arsenopyrite, cobalt, probably in the form of both cobaltite and smaltite and erythrite, the cobalt bloom. Associated with these minerals are considerable values in gold. A small amount of silver is also present.

Gross weight of sample received, 870 pounds.

This sample was crushed to 10 mesh in a small jaw crusher and set of rolls and a sample obtained for small scale tests and for analysis. The analysis of the sample showed the ore to contain:—

Molybdenite (MoS_2)	1·98 per cent.
Molybdite (MoO_3)	0·10 "
Cobalt (Co)	0·96 "
Arsenic (As)	3·82 "
Gold (Au)	1·32 oz.
Silver (Ag)	0·12 "

The tests on this ore were conducted to obtain a separation of the mineral constituents of the ore and so concentrate them into commercial products. This was done along the following lines:—

Firstly.—The separation of the molybdenite values by oil flotation, to obtain a commercial molybdenite product.

Secondly.—The separation of the other sulphides from the gangue, to obtain a smelter product, carrying the arsenic, cobalt, and gold values.

Thirdly.—The further recovery of the gold value if necessary in the tailing after the separation of the above products.

Small Scale Test.—A sample of the ore cut out from the original head sample was ground to 48 mesh (Tyler's standard); 1,000 grams was taken and mixed in a pebble jar with oil mixture, 1 pound coal oil per ton, ¼ pound crude turpentine per ton and a little water, for ten minutes. It was then added to the laboratory Callow flotation machine from which three products were made, namely, a molybdenite concentrate, a middling and tailing. The middling and tailing were combined and run over a small Wilfley table to obtain a separation of the other sulphides. A table concentrate, a middling and tailing were made:—

The results of this test are tabulated below:—

Product.	Dry Wt. Gms.	Analysis.				Content.				Percentages.			
		% MoS_2	% Co.	% As.	Ozs. Au.	Gms. MoS_2.	Gms. Co.	Gms. As.	Gram.-oz. Au.	% MoS_2.	% Co.	% As.	% Au.
Molybdenite concentration test.	31	50·00	0·80	2·45	3·60	15·5000	0·2480	0·7595	1·1160	78·28	2·58	1·99	8·45
Table conc. test....	49	1·00	11·12	38·00	4·25	0·4900	5·4488	18·6200	2·0825	2·47	56·76	48·74	15·78
Table middlings...	58	1·64	1·70	4·56	1·82	0·9512	0·9860	2·6448	1·0556	4·80	10·27	6·92	8·00
Table tails...	531	0·29	0·44	1·60	0·32	1·5399	2·3364	8·4960	1·6992	7·78	24·34	22·24	12·87
Slime loss, etc.....	331	0·40	0·18	23·20	2·19	1·3189	6·5808	7·6797	7·2467	6·66	6·05	20·11	54·90
Crude ore.........	1000	1·98	0·96	3·82	1·32	19·8000	9·6000	38·2000	13·2000	99·99	100·00	100·00	100·00

Summary.—From the above results the following deductions are made:—

Molybdenite.—The molybdenite concentrate made gave an analysis of 50·00 per cent MoS_2. This low grade of cencentrate is usual in test work on the laboratory machine. Much better results are always obtained in practice, the grade of the concentrate increasing with the better manipulation of the machines.

A recovery of 78·28 per cent of the molybdenite values in the ore is contained in the concentrate. This recovery should easily be reached in actual practice.

Cobalt.—The table concentrate made gave an analysis of 11·12 per cent Co, with a recovery of 56·76 per cent of the cobalt values in the ore. The table middling made gave an analysis of 1·70 per cent Co, representing 10·27 per cent of the cobalt values in ore. This middling product would be returned to the circuit in practice. The total recovery of the cobalt values in the concentrate would be around 65 per cent.

Arsenic.—The table concentrate made gave an analysis of 38·00 per cent As., with a recovery of 48·74 per cent of the arsenic values in the ore. The table middling made gave an analysis of 4·56 per cent As., representing 6·92 per cent of the arsenic values in the ore. This middling product would be returned to the circuit in practice. The total recovery of the arsenic values in the concentration would be around 55 per cent.

Gold.—The above test shows that 8·45 per cent of the gold values remained in the molybdenite concentrate. These gold values are not in the molybdenite but in the other sulphides and would report to a large extent in the molybdenite tails in raising the grade of the concentrate by wet screenings in the mill circuit, the molybdenite flake staying on the screen while the fine iron sulphides pass through and back into the circuit. The table concentrate shows a recovery of 15·78 per cent of the gold values while the losses show 54·90 per cent of the gold values. It was supposed that in crushing to 48 mesh the gold was freed and caught on the blankets of the flotation cells, and only the gold that was not freed from the sulphides was recovered. If this is the case, the recovery of the gold values would show 70·68 per cent.

Large Scale Test.

For the large scale test the ore was run through the molybdenite circuit. The ore was already crushed to 10 mesh, so it was fed direct to the ball mill. Our practice is to first crush in a jaw crusher to 1½-inch and feed automatically to the ball mill. The oil mixture is added to the ball mill and enters the mill with the ore feed. The discharge from the ball mill runs down a launder to a 3-inch centrifugal pump which lifts the pulp onto one-half of a Callow screen fitted in this case with a 60-mesh ton-cap screen, the oversize from the screen being returned to the mill while the undersize goes direct to the rougher cell. This is not the common practice with molybdenite ores. A Dorr classifier is generally used instead of the screen after the ball mill. From the rougher cell a rougher concentrate and a tailing is made, the rougher concentrate going to the cleaner cell while the tailing from this ore was held in a tank for further treatment on the concentrating tables. From the cleaner cell, the concentrates were drawn off over the front of the cell to an elevator and elevated onto the other half of the Callow screen fitted with an 80-mesh ton-cap screen. The undersize from the screen going back to the rougher cell while the oversize was caught as molybdenite concentrates. The tailings from the cleaner cell are also returned to the head of the rougher cell. The object of screening the cleaner concentrates is to drop the fine iron sulphides through the screen, while the molybdenite due to the coagulation of the particles by the oil is held on the screen. The oil used on molybdenite ores, while having a preferential action for this mineral is not complete and fine particles of other sulphides will float with the molybdenite, hence the necessity for screening in this manner the cleaner concentrates.

Due to such a small amount of the ore on hand clean quartz was first added to the mill to help fill up the mill circuit before proceeding with the molybdenite.

After the operation was complete, the Callow cells were cleaned out as well as possible and this clean up dried, weighed and sampled.

The results of the test are tabulated below:—

Quartz added to mill	373	pounds.
Ore to mill	765	"
Total	1,138	"

Molybdenite Concentration of Crude Ore.

Product.	Dry Wt. Lbs.	Analysis.					
		% MoS_2.	% MoO_3.	% Co.	% As.	Oz. Au.	Oz. Ag.
Molybdenite concentrate......	14·5	53·50	....	0·30	0·43	1·40	....
Clean up of cell.............	83·0	4·77	....	0·85	2·17	1·33	....
Molybdenite tailing..........	1000·0	0·35	....	0·70	1·55	0·30	....
Losses in circuit.............	40·5	....	....	....	29·37	14·30	....
Crude ore....................	765	1·98	0·10	0·96	3·82	1·32	0·12

Product.	Contents.				Percentages.			
	Lbs. MoS_2.	Lbs. Co.	Lbs. As.	Oz. Au.	% MoS_2.	% Co.	% As.	% Au.
Molybdenite concte..	7·7575	0·0435	0·0624	0·01015	51·21	0·59	0·21	2·01
Clean up of cell....	3·9591	0·3855	1·8011	0·05520	26·14	5·25	6·17	10·93
Molybdenite tailing..	3·5000	7·0000	15·5000	0·15000	23·11	95·31	53·04	29·71
Losses in circuit	0·0696	0·0850	+11·8595	+0·28955	− 0·46	− 1·15	+40·58	+57·35
Crude ore	15·1470	7·3440	29·2230	0·50490	100·00	100·00	100·00	100·00

Table Concentration of Molybdenite Tailing.

Product.	Dry Wt. Lbs.	Analysis.					
		% Mo S_2.	% Mo O_3.	% Co.	% As.	Oz. Au.	Oz. Ag.
Table concentrate	25	2·97	....	9·30	33·56	7·55	....
Table middling	26	1·25	....	1·55	4·32	0·89	....
Table tailing..............	949	0·26	....	0·27	0·39	0·08	....
Slime loss.................	....	....	....	....	....	....	....
Molybdenite tailing..........	1000	0·35	....	0·70	1·55	0·30	......

Product.	Contents.				Percentages.			
	Lbs. MoS_2.	Lbs. Co.	Lbs. As.	Oz. Au.	% MoS_2.	% Co.	% As.	% Au.
Table concentrate...	0·7425	2·3250	8·3900	0·09437	4·90	31·66	28·71	18·69
Table middling......	0·3250	0·4030	1·1232	0·01157	2·14	5·49	3·84	2·29
Table tailing........	2·4674	2·5623	3·7011	0·03796	16·22	34·90	12·67	7·52
Slime loss	−0·0349	+1·7097	+2·2857	+0·00610	− 0·15	23·26	7·82	1·21
Molybdenite tailing.	3·5000	7·0000	15·5000	0·15000	23·11	95·31	53·04	29·71

Summary.—From the above results the following deductions are made:—

Molybdenite.—The molybdenite concentrate made gave an analysis of 53·50 per cent MoS_2 with a recovery of 51·21 per cent of the molybdenite values in the ore. To this must be added the molybdenite values in the clean up of the cells, making a total recovery of molybdenite values, 77·35 per cent. This recovery can be worked up in practice, as well as the grade of the concentrate. The low grade of the concentrate is due to having to run the cells so long in order to obtain as much of the molybdenite values as possible in the concentrate. The cobalt, arsenic and gold values in this concentrate can also be reduced by careful manipulation as they are contained in the

fine sulphides other than molybdenite in the concentrates. A screen test was made on a sample of the concentrate, and analyses of the screen sizes were made as follows:—

Screen Sizes.	Weight Grams.	Analysis.			
		% MoS_2.	% Co.	% As.	Oz. Au.
+ 100	599	60·25	0·15	0·26	0·38
−100 + 150	209	54·35	0·18	0·24	0·35
−150 + 200	168	51·25	0·32	0·42	0·65
−200	615	49·70	0·48	0·61	3·00

From the above screen test it is shown that practically all the gold values can be eliminated from the molybdenite concentrates by careful work on the concentrate screen.

Cobalt.—The table concentrates gave a product 9·30 per cent Co. with a recovery of 31·66 per cent of the cobalt values in the ore. To this is added the cobalt in the middling, making the total recovery 37·15 per cent. From the above table of results it is shown that there has been a large loss in the tailing and in slime. This is very likely due to the cobalt occurring as bloom, as the sulphide and arsenide would concentrate more readily from the gangue.

Arsenic.—The table concentrate gave a product, 33·56 per cent arsenic having a recovery of only 28·71 per cent of the arsenic values in the ore, with the additional 3·84 per cent arsenic in the middling, makes a total recovery of 32·55 per cent. From the above table of results it will be noted, however, that 40·58 per cent of the arsenic values were lost in the mill circuit. The heavy arsenopyrite and iron pyrites in the ore remained to this extent in the ball mill, pump and pipe lines, and so were not recoverable on the table. If this percentage is added, the total recovery of the arsenic values would be 73·13 per cent.

Gold.—The table concentrates gave a product, 7·55 ozs. gold to the ton. The recovery in this concentrate was only 18·69 per cent of the gold values in the ore. The remaining gold values are accounted for as follows:—

In the molybdenite concentrate	2·01	per cent.
In the clean up of the cells	10·93	"
In the table middling	2·29	"
Losses in circuit	57·35	"
In the tailing	8·73	"

The gold values in the heavy sulphides were held up with the arsenopyrite and iron sulphides in the circuit along with any free gold. The free gold would also be caught in the canvas bottoms of the flotation cells. The actual losses of gold values not recoverable in actual practice would be the loss in molybdenite concentrate, which in the above test was 2·01 per cent and the loss in table tailing which was 8·73 per cent, making a total of 10·74 per cent. In actual practice a recovery of about 90 per cent of the gold values should be expected.

Conclusions.—From the test work conducted so far on this ore, it has been proven that the molybdenite values can be recovered by oil flotation with a recovery of from 75 per cent to 80 per cent; that the grade of the molybdenite concentrate can be improved and practically all the gold values removed by careful screening of the cleaner cell concentrate.

It has also been proven that by table concentration of the molybdenite tailing, the cobalt, arsenic, and gold values can be concentrated into a smelter product. This product should contain in actual practice 90 per cent of the gold values, with a fair concentration of the cobalt and 73 per cent of the arsenic values.

Instead of table concentration of the molybdenite tailing it may be advisable to regrind and refloat in another set of cells, recovering the gold values in this manner, similar to the practice at Cobalt, Ontario. A comparison of the two methods of recovering the gold values in the ore should be made.

It has also been proven that the sample of ore submitted contains free gold. An amalgamation test was made to prove whether the ore could be amalgamated before concentration. It was found out, however, that trouble would be experienced as with the case of all arsenopyrite ores and should not be resorted to if a good recovery can be made by other methods. The results of the test work on this ore has been so encouraging, that it would be advisable to continue with it on a larger scale. With a run on a carload lot, the losses in circuit would be minimized, the flotation cells would work more satisfactorily and a comparison of table concentration of the molybdenite tailing and reflotation of this tailing to recover the gold values could be made.

Test No. 84.

ZINC-LEAD ORE.

A sample of a few pounds of zinc-lead ore was received for analysis and report as to its adaptability to concentration.

This ore was submitted by Dr. Wilson, and was from Carmacks, Yukon territory.

On examination it was found that a portion of the iron sulphides was fairly coarsely crystalline, but that the zinc and lead were intimately associated.

A small test was run on the laboratory Callow pneumatic machine for concentration by oil flotation. The results obtained were not satisfactory, but would lead one to assume that with careful research work a separation might be effected in this manner. Another test was made on a small Wilfley table, to ascertain the results by water concentration. From this test it was found that a large percentage of the iron could be removed in the tailing and that the concentrate, middling, and slimes might be further concentrated by oil flotation.

The results of these tests were as follows:—

Original sample—Zinc	1·19 per cent.
Lead	0·94 "
Ag	2·15 oz.
Oil flotation test—(1,000 grams used).	
Concentrate	47·4 grams.
Analysis—Zinc	13·52 per cent.
Lead	11·15 "
Middling	44·2 grams.
Zinc	2·55 per cent.
Lead	2·68 "
Tailing	862 grams.
Zinc	0·94 per cent.
Lead	0·27 "
Table test	1,720 grams used.
Concentrate	44 grams.
Zinc	13·69 per cent.
Lead	6·98 "
Middling	247 grams.
Zinc	2·03 per cent.
Lead	1·26 "
Tailing	1,150 grams.
Zinc	0·73 per cent.
Lead	0·20 "
Slime loss	279 grams.

Conclusions.—The ore for the above tests was crushed to pass 50 mesh. The tests prove that this is not fine enough to obtain a good separation. A separation to a certain extent has been made both by oil flotation and table concentration. The

flotation test is the better of the two methods and would have to be resorted to in the concentration of an ore of this class where very fine crushing is necessary. A combination of both table concentration followed by oil flotation would probably be the better method of concentration.

Test No. 85.

GRAPHITE CONCENTRATES.

A shipment of two bags, 200 pounds of graphite concentrates, was received on January 25, 1918, from the New Quebec Graphite Co., Ltd., Buckingham, Que.

This graphite was their concentrate from some point in their milling operations, and contained as impurities, quartz adhering to the graphite flake, mica, and a small amount of iron sulphides.

The analysis of this shipment showed it to contain:—

Carbon	60·10 per cent.
Silica	20·10 "
Iron	2·20 "

The product desired was a commercial graphite flake as high in carbon as possible to obtain.

Tests were made on the Huff electrostatic separator to remove the mica, without appreciable results. Some of the mica was removed but at the expense of a large loss of the graphite flake.

A test was run on the large Callow pneumatic machine, the concentrate being fed in the head of the rougher cell with water, a little coal oil and pine oil being added. The analysis of the concentrate made was as follows:—

Carbon	72·30 per cent.
Silica	11·20 "
Iron	2·30 "

On examination of this concentrate it was found that the mica was eliminated but the quartz adhering to the graphite flake remained.

The iron content was practically the same. It is doubtful whether this came from the graphite concentrate or was picked up in the air lifts of the cells from former tests on molybdenite ores.

To make a clean concentrate it was necessary to regrind, to free the quartz gangue adhering to the flake. This was done in the wet ball mill using pebbles for grinding. An accurate test could not be made as the amount of concentrate was too small. The mill was charged with 380 pounds of pebbles, 122 pounds of concentrate, and 122 pounds of water, and allowed to run for 30 minutes.

A screen test was made on the concentrate before grinding and also on the concentrate after grinding and refloating. From the screen test scales submitted in this report it will be found that the grinding produced 10 per cent more fines than in the original concentrate. This is probably high to what it would be in actual practice as it has been found that with careful operation the regrinding with pebbles does produce but very little more fines than the feed, and frees the flake from the adhering gangue.

The analysis of the final concentrate was as follows:—

Carbon	83·45 per cent.
Silica	6·50 "
Iron	2·00 "

Conclusions.—The above test shows that a considerable improvement has been made on the grade of the concentrate. The concentrate was screened on 100, 150, and 200 Tyler standard screens with the following results:—

+100—78·2 per cent of concentrate.	
Analysis—C	86·50 per cent.
SiO_2	4·30 "
—100+150—13·3 per cent of concentrate.	
Analysis—C	82·05 per cent.
SiO_2	11·90 "
—150+200—3·8 per cent of concentrate.	
Analysis—C	68·45 per cent.
SiO_2	17·00 "
—200—4·7 per cent of concentrate.	
Analysis—C	48·32 per cent.
SiO_2	19·40 "

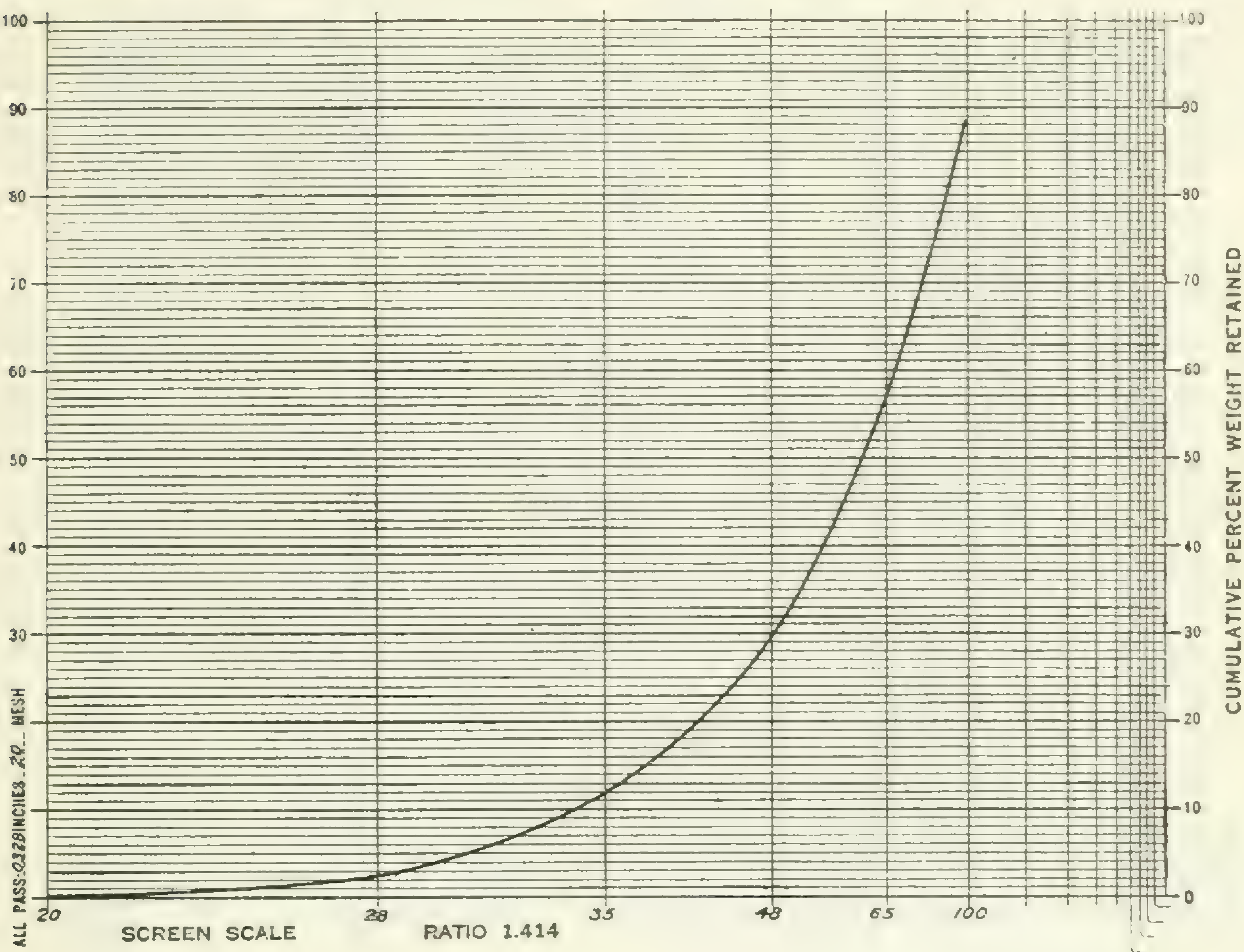
From the + 28 size, the larger pieces of clean flake were picked out and analysed as follows:—

Carbon	92·25 per cent.
Iron and alumina	3·60 "
Lime and magnesia	Absent.
Insol. silica	3·00 per cent.
Volatile and undetermined	1·15 "

This analysis determines the limit of concentration without crushing the flake finer, as the gangue is included in the flake itself.

SESSIONAL PAPER No. 26a

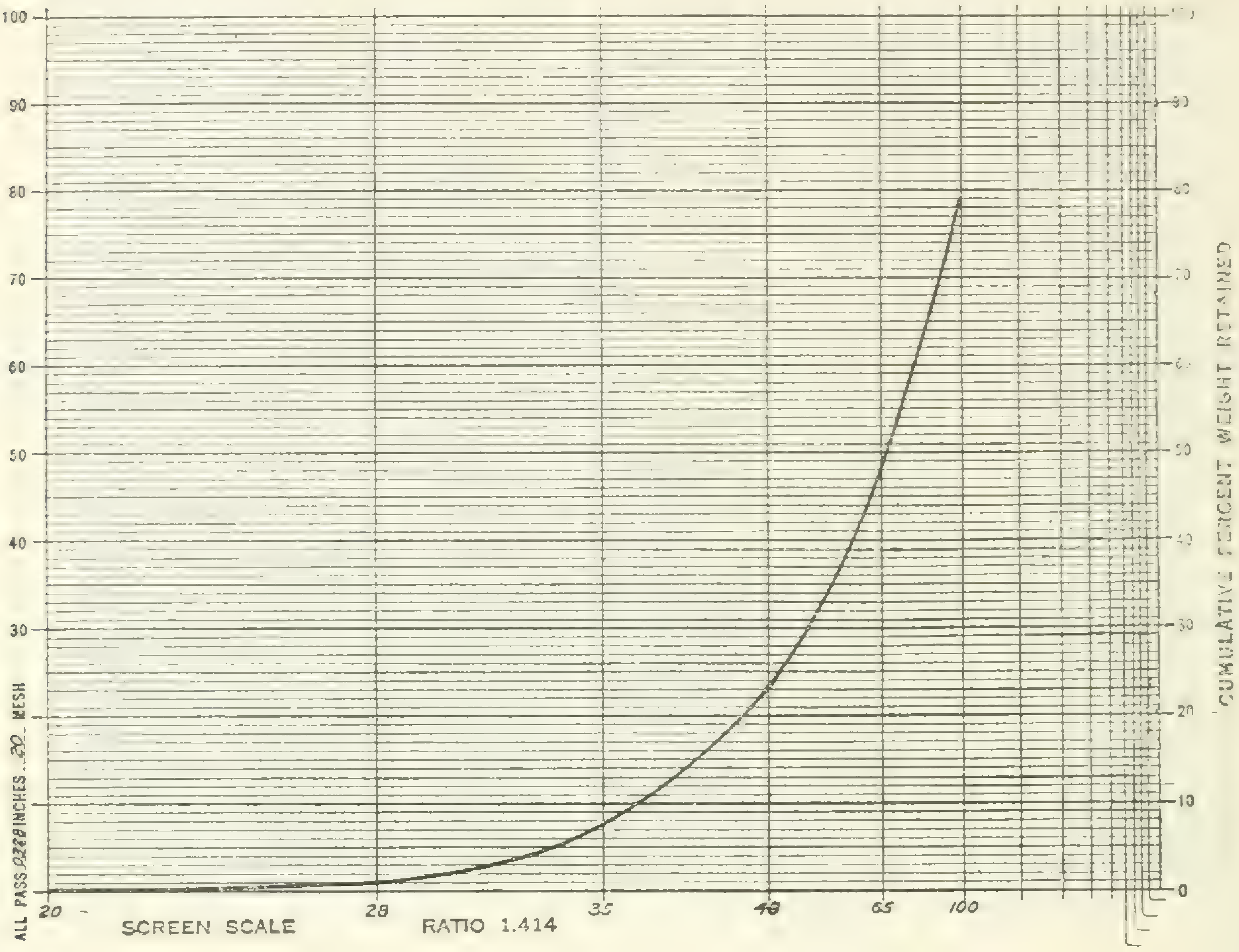
Cumulative Direct Diagram of Screen Analysis on Sample of *Graphite Conc^tes before grinding*
Name *W. B. Timm* Date *April 27th, 1918.*



Indicate the Screen Crushed Through and also First Retaining Screen.	Screen Scale Ratio 1·414. Openings. Inches.	Millimeters.	Mesh.	Diameter Wire Inches.	Sample Weights	Per Cent.	Per Cent Cumulative Weights
....	1.050	26·67	......	·149	......	......	......
....	·742	18·85	......	·135	......	......	......
....	·525	13·33	......	·105	......	......	......
....	·371	9·423	......	·092	......	......	......
....	·263	6·680	3	·070	......	......	......
....	·185	4·699	4	·065	......	......	......
....	·131	3·327	6	·036	......	......	......
....	·093	2·362	8	·032	......	......	......
....	·065	1·651	10	·035	......	......	......
....	·046	1·168	14	·025	......	......	......
All these	·0328	·833	20	·0172	......	......	......
....	·0232	·589	28	·0125	19	2·2	2·2
....	·0164	·417	35	·0122	89	10·1	12·3
....	·0116	·295	48	·0092	157	17·9	30·2
....	·0082	·208	65	·0072	238	27·1	57·3
....	·0058	·147	100	·0042	273	31·1	88·4
Pass 100	......	......	......	......	101	11·5	11·5
Totals	......	......	......	......	877	99·9	......

Diagram VII.

Cumulative Direct Diagram of Screen Analysis on Sample of *Graphite Conc^tes after grinding*
Name *W. B Timm* Date *April 27th, 1918.*



Indicate the Screen crushed through and also First Retaining Screen.	Screen Scale Ratio 1·414. Openings. Inches.	Milli-meters.	Mesh.	Diameter Wire Inches.	Sample Weights	Per Cent.	Per Cent Cumulative Weights
	1·050	26·67		·149			
	·742	18·85		·135			
	·525	13·33		·105			
	·371	9·423		·092			
	·263	6·680	3	·070			
	·185	4·699	4	·065			
	·131	3·327	6	·036			
	·093	2·362	8	·032			
	·065	1·651	10	·035			
	·046	1·168	14	·025			
All these	·0328	·833	20	·0172			
	·0232	·589	28	·0125	3	0·46	0·5
	·0164	·417	35	·0122	48	7·4	7·9
	·0116	·295	48	·0092	99	15·3	23·2
	·0082	·208	65	·0072	167	25·7	48·9
	·0058	·147	100	·0042	190	29·3	78·2
Pass 100					141	21·8	21·8
Pass							
Totals					648	100·0	

Diagram VIII.

Test No. 86.

MOLYBDENITE ORE FROM HALEYS, ONT.

A shipment of 20 sacks of molybdenite ore was received May 1 from J. F. Day, Sudbury, Ont. This shipment came from a property near Haleys Station, Ont.

The molybdenite was of the flake variety, in quartz. Very little mica or iron sulphides was present.

Gross weight received	2,601 pounds.
Net weight received	2,584 "
Moisture	0·18 per cent.
Net dry weight	2,579 pounds.
Analysis—MoS_2	1·97 per cent.
Content—MoS_2	50·8063 pounds.

Small Scale Tests.—A sample of the ore was crushed to pass 40 mesh from which 1,000 grams were taken for a test on the laboratory Callow flotation machine.

Oil mixture added	2 pounds coal oil per ton. ½ pound pine oil per ton.
Concentrate obtained	18·5 grams.
Analysis—MoS_2	76·28 per cent.
Content—MoS_2	14·1118 grams.
Recovery	83·0 per cent.
Middling obtained	101 grams.
Analysis—MoS_2	1·09 per cent.
Content—MoS_2	1·1009 grams.
Percentage MoS_2 values	6·00 per cent.
Tailing obtained	880·5 grams.
Analysis—MoS_2	0·20 per cent.
Content—MoS_2	1·7610 grams.
Loss	11·0 per cent.

Figuring on a recovery of 70 per cent of the molybdenite values in the middling, the total recovery would be 87 per cent.

Four hundred and sixty-five grams of ore crushed to 40 mesh were used for a test on the Janney laboratory flotation machine. Oil mixture same as former test.

Concentrate obtained	7·5 grams.
Analysis—MoS_2	80·35 per cent.
Content—MoS_2	6·02625 grams.
Recovery	89·6 per cent.
Middling obtained	43 grams.
Analysis—MoS_2	1·09 per cent.
Content—MoS_2	0·4687 grams.
Percentage MoS_2 values	7·0 per cent.
Tailing obtained	414·5 grams.
Analysis—MoS_2	0·055 per cent.
Content—MoS_2	0·2280 grams.
Loss in tailing	3·4 per cent.

Figuring on a recovery of 70 per cent of the molybdenite values in the middling, the total recovery would be 94·5 per cent.

Large Scale Test.—The ore which was already crushed for sampling was run through the regular molybdenite circuit. It was fed to the ball mill, where the oil mixture was added. The discharge of the mill passed over a Callow screen, fitted with a 45-mesh ton-cap screen, the oversize returning to the mill, while the undersize went direct to the flotation machines. Only two products were made, a concentrate and a tailing.

Concentrate obtained	65 pounds.
Analysis—MoS_2	69·77 per cent.
Content—MoS_2	45·3505 pounds.
Recovery	89·1 per cent.
Tailing to waste	2,514 pounds.
Analysis—MoS_2	0·22 per cent.
Content—MoS_2	5·5308 pounds.
Loss	10·9 per cent.

Conclusions.—Ore is very easily concentrated and would in actual practice produce a very high grade concentrate with a high recovery of the molybdenite values. A concentrate of 85 to 90 per cent grade should be obtained with a recovery of 95 per cent of the molybdenite values.

Test No. 87.

WOLFE CO., QUE., GOLD QUARTZ.

Two shipments of gold-bearing quartz was received from Lake Aylmer, Wolfe county, Que. These shipments were submitted by Chas. J. Wallich, Detroit, Michigan.

Shipment No. 1 was received on January 4, 1918.

Net weight	238 pounds.
Analysis—Au	0·06 oz.

Shipment No. 2 was received March 18, 1918.

Net weight	343 pounds.
Analysis—Au	0·04 oz.

The ore consisted of narrow bands of quartz in a schist formation. No free gold was visible.

Cyanide tests were made on shipment No. 1, on portions crushed to 50 mesh and to 100 mesh.

Strength of cyanide solution used was 0·15 per cent.

Weight of ore taken—300 grams.

Amount of solution used—1,000 c.c.

Duration of agitation—24 hours.

Solution decanted off and tailings washed, dried and analysed.

Tailing—50-mesh material—Au.—0·02 ounces.

Tailing—100-mesh material—Au.—trace.

Test No. 88.

CONCENTRATION TESTS ON PYRITE ORE.

A shipment of three bags of pyrite ore was received on April 9, 1918, from Robert Gamble, Ottawa, Ont.

This ore was obtained from the surface showings and was much oxidized. This pyrite was finely crystalline. Very little gangue material was present. The object of the test was to raise the sulphur content to a commercial grade.

As the pyrite present was finely crystalline, tests were made on the ore crushed to different meshes and the ore concentrated on tables.

It was crushed to 10 mesh and sampled.

Weight received	460 pounds.
Analysis—S	20·93 per cent.
Fe	52·90 "
Cu	Trace.

It was divided into four lots by means of the Jones riffled sampler. One lot was left at 10 mesh. Another lot was crushed to pass 20 mesh, and another to pass 30 mesh, and another to 40 mesh.

Each lot was concentrated separately on an Overstrom table and the products weighed and analysed. The results of the tests are contained in the following table:—

Crude Ore.		Concentration Products.				Handling and slime loss.
Mesh.	Weight.	Product.	Weight.	Analysis.		
	Lbs.		Lbs.	% S.	% Fe.	Lbs.
		Concentrate........	69	22·62	54·00	
10 mesh.......	113	Middling...........	5	22·54	53·60	14
		Tailing.............	25	17·16	51·60	
		Concentrate.........	30·5	23·52	....	
20 mesh.. . .	110·5	Middling..........	30	23·20	....	24
		Tailing.............	26	19·67	52·00	
		Concentrate........	31·5	25·22	....	
30 mesh.......	115	Middling.........	41·5	23·10	....	26·5
		Tailing............	15·5	17·23	....	
		Concentrate.........	27	26·00	....	
40 mesh.......	113·5	Middling...........	37·5	23·92	....	31·5
		Tailing..........	17·5	17·98	....	

Summary and conclusion:—

This ore was taken from the surface showings and is much oxidized so that it contains all the oxidation products from the sulphide to the oxide and were it not for this oxidization would be practically a pure sulphide containing Fe—46·6 per cent, S.—53·4 per cent. A very pure pyrite ore, requiring no concentration, should be obtained at depth, or after the oxidization zone had been penetrated.

Table concentration improved the grade slightly, as there is a small difference in the gravity of the sulphide and the oxide; more sulphide reporting in the concentrate and more of the oxide in the tailing.

A separation could be made by magnetic concentration and by oil flotation but this would not be permissible on account of the fineness of the concentrate produced.

The copper content is too low to be of any commercial value, only a trace being found in the head sample.

Test No. 89.

GOLD ORE FROM SUDBURY, ONT.

A shipment of 3½ bags of gold ore was received on December 11, 1917, from J. S. Black, Sudbury, Ontario.

Gross weight received..	220 pounds.
Net weight received..	215 " "
Analysis—gold..	1·70 oz. per ton.

The gold was associated with arsenopyrite in the ore and although free gold was visible to the naked eye it was proven that it was not free milling.

Tests were conducted to recover the gold values by amalgamation, by table concentration and flotation, and by cyaniding the table tailing.

The ore was first crushed to pass 40 mesh and sampled, from which the above analysis of 1·70 oz. to the ton was obtained. A portion of this sample was held for a flotation test.

Amalgamation.—The ore crushed to pass 40 mesh less the sample was panned to recover any free gold. It was given a second panning to see if any more gold values were recoverable by this method.

Tailing after 1st amalgamation—1·20 oz. gold per ton.

Tailing after 2nd amalgamation—1·13 oz. gold per ton.

Recovery by amalgamation—33·5 per cent of gold value

Table concentration.—The tailings from the amalgamation tests were concentrated on an Overstrom table with the following results:—

Weight of pulp to table	20·0 pounds.
Analysis—gold	1·13 oz.
Content—gold	0·113 "
Concentrate obtained	17 pounds.
Analysis—gold	7·15 oz.
Content—gold	0·0608 oz.
Recovery of gold values	53·8 per cent.
Middling obtained	74 pounds.
Analysis—gold	0·74 oz.
Content—gold	0·0274 oz.
Percentage of gold values	24·3 per cent.
Tailing obtained	54 pounds.
Analysis—gold	0·34 oz.
Content—gold	0·0092 oz.
Percentage of gold values	8·1 per cent.
Slime loss	55 pounds.
Analysis—gold	0·57 oz.
Content—gold	0·0156 oz.
Percentage of gold values	13·8 per cent.

Figuring on a recovery of 70 per cent of the gold values in the middling being recovered with the concentrate in returning the middling to the milling circuit in actual practice, the recovery by table concentration would be 70·8 per cent. This would leave 29·2 per cent of the gold values left in the slime and table tailings. The slime loss from the table concentration would not be a loss if further treatment by cyanidation would be resorted to.

Flotation Concentration.—A sample of the crude ore crushed to 40 mesh was taken for this test, and the concentration made on the Callow pneumatic testing machine.

Ore used	1,000 grams.
Oil used	2 pounds per ton of mixture.
	10 per cent coal tar.
	50 " " creosote.
	40 " hardwood oil F.P.L. No. 26.

Concentrate obtained	151 grams.
Analysis—gold	7·54 oz. per ton.
Content—gold	11·3854 gram-oz.
Recovery of gold values	67·0 per cent.
Middling obtained	77 grams.
Analysis—gold	1·06 oz. per ton.
Content—gold	0·8162 gram-oz.
Percentage of gold values	4·8 per cent.
Tailing obtained	772 grams.
Analysis—gold	0·62 oz. per ton.
Content—gold	4·7864 gram-oz.
Percentage of gold values	28·2 per cent.

Figuring on a recovery of 70 per cent of the gold values in the middling being recovered with the concentrate in actual practice, the recovery by flotation would be 70·4 per cent. This would leave 29·6 per cent of the gold values left in tailing, which would have to be cyanided. Finer grinding would no doubt give a better recovery by this method.

Cyanidation.—Tests were made on the table middling and the table tailing. A sample of each of these products was ground to pass a 100-mesh screen.

Middling—Analysis—gold	0·76 oz. per ton.
Amount of middling taken	200 grams.
Amount of solution used	1,000 c.c.
Strength of solution used	0·15 per cent.
Lime added	1 gram.
Duration of agitation	12 hours.
Analysis of tailing	0·26 oz. per ton.
Recovery of gold values in middling	65 per cent.
Consumption of cyanide	2·5 pounds per ton.

Tailing—Analysis—gold	0·34 oz. per ton.
Amount of tailing taken	200 grams.
Amount of solution used	1,000 c.c.
Strength of solution used	0·15 per cent.
Lime added	1 gram.
Duration of agitation	12 hours.
Analysis of tailing	0·02 oz. per ton.
Recovery of gold value in table tailing	94 per cent.
Consumption of cyanide	0·5 pounds per ton.

It will be noted that a poor extraction is made on the table middling but that a high recovery is made on the table tailing. The consumption of cyanide is high on the middling and comparatively low on the tailing for this class of ore. The low extraction and high consumption of cyanide on the middling is due to the arseno pyrites remaining in this product. The test was run on the middling to determine this point.

Conclusions.—Amalgamation should not be resorted to on this ore. Trouble would be encountered in keeping the plates clean which together with the loss in mercury would prohibit its use.

Table concentration and cyanidation of the table tailings seems to be the better method of procedure with an ore of this class. A recovery of 70 per cent of the gold values in the ore should be obtained in the table concentrates. A further recovery of $30 \times 94 \div 100 = 28{\cdot}2$ per cent of the gold values in the ore should be obtained by cyaniding the table tailing, making a total recovery of 98 per cent of the gold values in the ore.

Flotation concentration and cyanidation of the flotation tailings would be equally as good were it not that trouble might be experienced in cyaniding the flotation tailing.

Test No. 90.

SCHEELITE CONCENTRATES FROM YUKON.

A shipment of three bags of scheelite concentrates was received Feb. 16, 1918, from Frank W. Canton. This shipment was made through G. D. Mackenzie, gold commissioner for the Yukon.

Gross weight of concentrate received	354 pounds.
Net weight of concentrate received	350 "
Analysis—WO_3	69·50 per cent.
Au	3·98 oz.
Content — WO_3	243·25 pounds.
Au	0·6965 oz.

This concentrate was amalgamated to extract the free gold. It was found that part of the gold was free and part still adhering to the quartz grains in the scheelite.

Weight after amalgamation	343·5 pounds.
Analysis—WO_3	70·88 per cent.
Au	1·91 oz.
Content — WO_3	243·47 pounds.
Au	0·328 oz.
Bullion recovered	0·237 "

In order to make a further recovery of the gold values it would be necessary to grind the concentrates to free the gold from the quartz. The loss in the scheelite would be greater than the recovery made on the gold so this was not resorted to. It would not be possible to make a separation by water concentration as the gold with adhering quartz particles has the same gravity as the scheelite.

Test No. 91.

MOLYBDENITE TAILING FROM HULL MILL.

A carload shipment of molybdenite tailing from the Hull plant of the Canadian Wood Molybdenite Co. was received on May 31, 1918, from the Wood Molybdenite Co., Ottawa, Ont.

Gross weight	59,026 pounds.
Moisture	5·66 per cent.
Net dry weight	55,685 pounds.
Analysis—MoS_2	0·55 per cent.
MoO_3	0·04 "
Content—MoS_2	306·27 pounds.

This carload was run through the regular molybdenite circuit as follows:—

It was first weighed, a moisture sample taken and sent to the ball mill through a Vezin sampler where the regular head sample was cut out. From the ball mill the pulp passed into a Callow screen fitted with a 45-mesh screen, the undersize going to the flotation cell, the oversize being returned to the ball mill. The oil mixture was added to the mill.

Oil mixture used—25%	No. 5 pine oil.
25%	F.P.L. No. 25 light hardwood creosote.
50%	Coal oil.

1½ pounds of this mixture was used per ton.

Concentrate obtained	129 pounds.
Analysis—MoS_2	41·27 per cent.
Content—MoS_2	53·24 pounds.
Recovery of—MoS_2	17·4 per cent.
Tailing to waste	55,556 pounds.
Analysis of tailing samples	0·45% MoS_2
Calculated analysis of tailing	0·455% MoS_2
Content—MoS_2	253·03 pounds.
Loss of MoS_2 values	82·6 per cent.

Conclusion.—The tailing was very badly oxidized and flotation was hindered by salts in solution. The flotation properties of the flake was destroyed partially through oxidization and partially by the previous drying of the ore. These are the main causes of the poor extraction and the low grade of concentrate.

To prepare the tailings for concentration they should be washed thoroughly to remove the salts which go into solution, thickened and reground in a tube mill to brighten up the flake, so that the oil will adhere to it and then it should be in shape for flotation.

Test No. 92.

MOLYBDENITE ORE FROM LOON LAKE, ONT.

On July 2, 1918, a sample of 502 pounds of molybdenite ore was received from J. A. Johnston, Loon Lake, Ont.

The molybdenite was of the flake variety in a quartz and feldspar gangue, practically free from other sulphides but containing a small amount of mica.

Net weight of ore received	502 pounds.
Analysis—MoS_2	2·14 per cent.
MoO_3	0·10 "
Content—MoS_2	10·7428 pounds.
MoO_3	0·5020 "

Tests were conducted on the laboratory flotation machines to determine the adaptability of the ore for concentration.

1,000 grams of the ore crushed to pass 48 mesh; ·0116″ aperture was taken for each test.

The oil used in each case was 1 pound of No. 5 pine oil per ton of ore, and 2 pounds of coal oil per ton of ore.

Each test was agitated in a pebble mill to obtain a mixture of the oil, water and ore for 10 minutes.

On test No. 1 only the tailing was analysed which gave 0·29% MoS_2.

On test No. 2 only the tailing was analysed which gave 0·19% MoS_2.

On test No. 3 all products were weighed and sampled with the following results:—

Concentrate obtained	21 grams.
Analysis—MoS_2	85·70 per cent.
Content—MoS_2	17·9970 grams.
Recovery of MoS_2	90·1 per cent.
Middling obtained	23 grams.
Analysis—MoS_2	2·77 per cent.
Content—MoS_2	0·6371 grams.
Percentage of MoS_2 values	3·2 per cent.
Tailing obtained	956 grams.
Analysis—MoS_2	0·14 per cent.
Content—MoS_2	1·3384 grams.
Loss of MoS_2 values	6·7 per cent.

Figuring on a recovery of 70% of the MoS_2 values in the middling, the total recovery would be 92·3% of the values in the crude ore.

Conclusions.—From the above results it has been determined that this ore can be easily concentrated. The laboratory tests show a concentrate of grade 85·70% MoS_2 with a recovery of 92·3% of the MoS_2 values. In practice better results should be obtained. On an ore of this class a concentrate of grade 90% with a recovery of 95% of the MoS_2 values could be expected.

Test No. 93.

A shipment of nine bags of molybdenite ore was received on June 30, 1918, from H. Leger, Campbell's Bay, Que.

Gross weight received	768 pounds.
Net weight received	759 "
Analysis—MoS_2	1·025 pounds.
Content—MoS_2	7·78 "

The molybdenite was of the flake variety in a pyroxenite gangue. Very little iron pyrites was present.

A test was made on the laboratory Callow flotation machine to determine its adaptability to concentration by oil flotation.

1,000 grams of the ore was used, crushed to pass 48 mesh, ·0116″ aperture.

The oil mixture was ½ pound of No. 5 pine oil and 1 pound coal oil per ton of ore.

The results of the test follow:—

Product.	Weight Grams.	Analysis % MoS_2	Content Gram MoS_2	Percentage of MoS_2 Values.
Concentrate	7	88·02	6·1614	70·4
Middling	379	0·41	1·5539	17·8
Tailing	614	0·17	1·0438	11·8

Conclusion.—It was found that the ore was an ideal one for concentration by this method. Containing very little iron pyrites, a high grade concentrate is easily made. A concentrate of grade 88·02% MoS_2 was made on the testing machine and a better grade should be made in practice. The above test shows that a good recovery can be obtained. Figuring on a recovery of 70% of the values in the middling, the total recovery would be 82·9% of the MoS_2 values in the crude ore.

Test No. 94.

Two samples of manganese ore was received on June 17, 1918, from W. F. C. Parsons, Bathurst, N. B.

These samples were marked Nos. 1 and 2 and contained pyrolusite, finely crystalline in a reddish slate gangue.

Concentration tests were made on a laboratory Wilfley table to determine their adaptability to concentration.

Both samples were ground to 50 mesh.

2,000 grams of sample No. 1 were taken.

1,000 grams of sample No. 2 were taken.

Sample No. 1 gave an analysis of:—

Mn.. .. .. 24·92% Fe.. .. .. 9·00%

Sample No. 2 gave an analysis of:—

Mn.. .. .. 16·20% Fe.. .. .. 8·10%

The results of the test work are contained in the following table:—

Sample No.	Product.	Weight Grams.	% Mn.	Analysis.		Content Mn. Grams	Percentage of Mn. Values.
				% Fe.	% SiO_2		
1	Concentrate....	589	41·97	10·0	17·15	247·20	49·6
	Middling, No. 1..........	61	25·82	11·6	....	15·75	3·2
	Middling, No. 2....... ..	179	12·72	11·7	....	22·77	4·6
	Tailing..................	568	5·51	.. ..	....	31·30	6·3
	Slime loss..............	603	30·08	....	....	181·38	36·4
	Totals and averages...	2,000	24·92	9·0	... .	498·40	100·1
2	Concentrate.............	98	48·35	7·1	9·20	47·38	29·3
	Middling.................	39	30·76	....	... .	12·00	7·4
	Tailing..........	526	9·33	....	.. ..	49·08	30·3
	Slime loss......	337	15·90	....	.... . .	53·54	33·0
	Totals and averages...	1,000	16·20	8·1	....	162·00	100·0

Conclusion.—From the above results, the concentration of this ore in practice would be for a manganese concentrate of grade 40%, a recovery of 50% to 60% of the manganese values, and for a manganese concentrate of grade approaching 50% a recovery of 30 to 40% of the manganese values.

Test No. 95.

Two shipments of ferro-molybdenum slag were received, one on May 6, 1918, and the other on May 10, 1918 from the Tivani Electric Steel Co., Belleville, Ont.

This slag was from the reduction of molybdenite concentrates into ferro-molybdenum in the electric furnace.

The test was conducted to concentrate the pellets of ferro-molybdenum which were shot through the slag and recover them as concentrate.

To accomplish this necessitated the grinding of the slag to free the ferro-molybdenum and concentration on tables to recover it.

Molybdenum values in the slag other than in the form of the metal could not be recovered by this method.

Slag received—Shipment No. 2	62,745	pounds.
Shipment No. 3	14,095	"
Total	76,840	"
Moisture—3·00%	2,305	"
Dry net weight	74,535	"
Analysis—Total Mo	4·22	per cent.
Mo as MoO_3	0·30	"
Mo as ferro	3·92	"
Content — Total Mo	3,145·3770	pounds.
Mo as MoO_3	223·6050	"
Mo as ferro	2,921·7720	"

A flow sheet showing the method of procedure follows:—

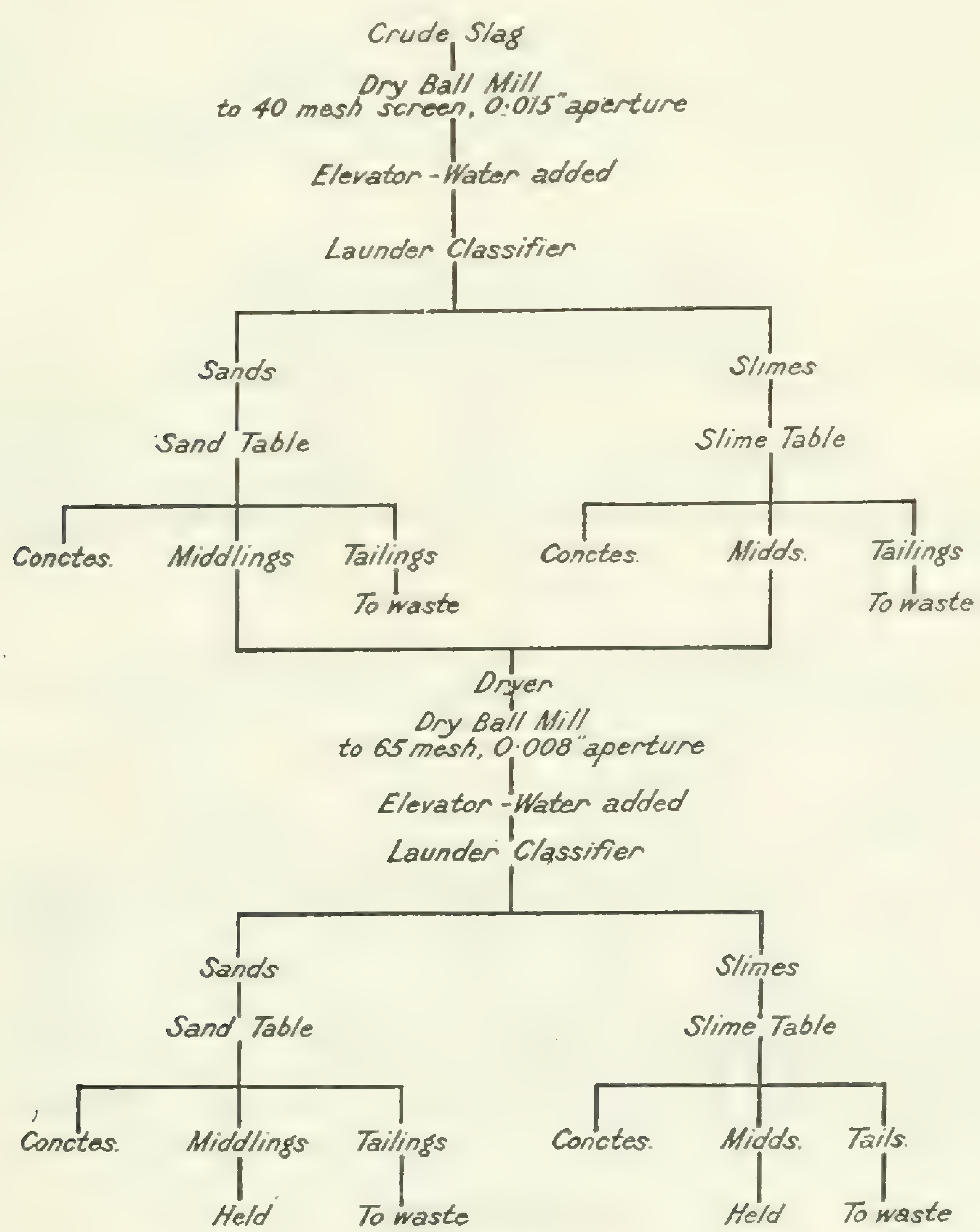


Fig. 6.—Flow sheet showing method of recovering ferro-molybdenum values from the slag of molybdenite concentrates.

As this slag contained a lot of steel turnings which got into it at the shipper's yards and these turnings were ground and reported in the concentrates from the tables, it was necessary to reconcentrate the concentrate to remove as much of them as possible.

The results of the concentration are contained in the following table:—

CONCENTRATION OF SLAG.

Crushed to 40 mesh, 0·015″ aperture.

Product.	Weight.	Analysis. Total Mo.	Analysis. Mo as MoO_3.	Content. Total Mo.	Per cent of Values. Mo.
	Lbs.	%	%	Lbs.	
Concentrate	3,192	56·41	....	1800·5754	57·25
Middling	17,668	3·37	0·44	595·4116	18·93
Tailing	53,675	1·48	0·37	749·3900	23·82
Totals and averages	74,535	4·22	0·30	3145·3770	100·00

CONCENTRATION OF MIDDLINGS.

Crushed to 65 mesh, 0·008″ aperture.

Concentrate	775	45·00	....	348·4908	11·08
Middling	130·5	31·22	....	40·7421	1·30
Tailing	16762·5	1·23	0·24	206·1788	6·55
Totals and averages	17668	3·37	0·44	595·4116	18·93

RECONCENTRATION OF CONCENTRATES.

To remove iron turnings crushed with slags.

Concentrate	3374	63·18	....	2131·6932	67·77
Middling	306	31·22	....	95·5332	3·03
Tailing	287	24·00	....	68·8800	6·55
Totals and averages	3967	57·89	....	2296·1064	72·99

SUMMARY OF PRODUCTS RECOVERED.

Product.	Weight.	Analysis. Mo.	Analysis. C.	Analysis. S.	Content. Mo.	Recovery of Values.
	Lbs.	%	%	%	Lbs.	Mo.
Concentrate	3,374	63·18	2·90	0·901	2131·6932	67·77
Middling	436·5	31·22	....	....	136·2753	4·33
Tailing	287	24·00	....	....	68·8800	2·19

Actual recovery of total molybdenum values in slag. 74·29 per cent.
MoO_3 values were all lost in the tailing.. .. .. ..
Recovery of ferro-molybdenum in slag.. .. .. 79·97 per cent.

Test No. 96.

Two samples of manganese ore were received on June 14, 1918, from Dr. Hayes of the Geological Survey. These samples were obtained from the farm of Mrs. Geo. Harrington, Gowland Mountain, N.B.

Sample marked "A" was high grade and gave the following analysis:—

Mn. .. .. .. 50·62% Fe. .. .. .. 0·30% SiO_2.. .. .. 15·00%

Sample marked "B" was low grade and gave the following analysis:—

Mn. . . . . 24·69% Fe. . . . . 3·00%

The manganese was in the form of pyrolusite, finely crystalline in a reddish slate gangue.

A test was made on 2,000 grams of B sample, crushed to 50 mesh, on the laboratory Wilfley table to determine its adaptability to concentration. The results follow:—

Product.	Weight grams.	Analysis.			Content.	Percentage of
		Mn.	Fe.	S.	Grams Mn.	Mo. Values.
		%	%	%		
Concentrate	433	52·29	3·50	9·85	226·416	45·85
Middling	101	32·50	3·45	......	32·825	6·65
Tailing	890	9·85	......	......	87·665	17·75
Slime loss	576	25·50	......	......	146·894	29·75
Totals and averages	2,000	24·69	......	......	493·800	100·00

Conclusions:—

In practice on an ore of this class to obtain a concentrate of grade 50 per cent manganese, a recovery of 50 per cent of the Mn. values could be expected. To obtain a concentrate of grade 40 per cent Mn. a recovery of 60 per cent could be expected.

Test No. 97.

A shipment of two bags of tailing of approximately 200 pounds from a former molybdenite plant at Hull, Que., was received on June 18, 1918, from the Wood Molybdenite Co., Ottawa, Ont.

These two bags were sampled in Jones riffled samplers and samples cut out for analysis, screen test and concentration tests on the laboratory flotation machines.

Analysis of shipment . . . . { 0·87% MoS_2 / 0·07% MoO_3 }

The results of the screen test are shown on the accompanying scale sheet.

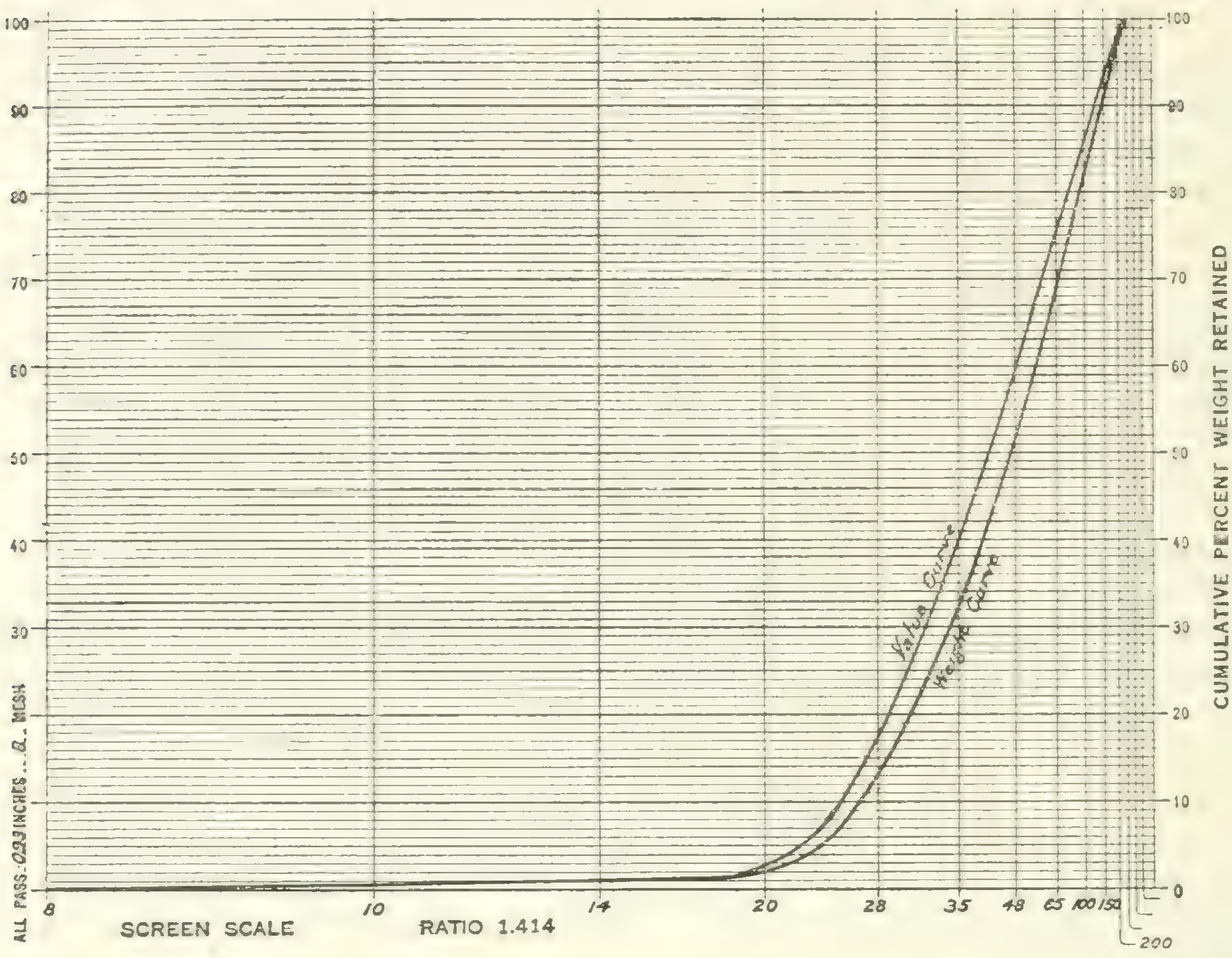
The results of the flotation tests are given in the following table.

Conclusion.—The screen test was made to determine just where the molybdenite values were. It was thought that practically all the values were in the coarse sizes. From the test it has been proven that 33% of the tailings by weight is finer than 65 mesh and contain 25·4% of the molybdenum values.

From the table giving the results of the flotation tests it will be seen that the tailing does not readily lend itself to oil flotation. In all cases the froth was not good, resulting in poor recoveries. Even on the washed tailing good results could not be obtained, the only reason for this being that the floating properties of the flake have been destroyed. This has been proven by the large amount of values contained in the middling, which ranges between 25 and 40% of the values in the crude. On an ordinary ore these values would not be above 10% and generally are around 5%. Recoveries in the table have been calculated on recovering 70% of these values, which is permissible with the raw ore, but it is doubtful if this can be obtained on this tailing.

It is possible that a method of treatment could be worked out that would be satisfactory but the amount of tailing to be treated would hardly warrant the installation of a plant and the preparatory work necessary before the plant would be in condition to give a satisfactory recovery.

Cumulative Direct Diagram of Screen Analysis on Sample of *Hull Tailings (O.E. Wood)*
Name *W. B. Timm* Date *June 17th 1918.*



Indicate the Screen crushed through and also First Retaining Screen.	Screen Scale Ratio 1·414. Openings. Inches.	Millimeters.	Mesh.	Diameter Wire Inches.	Sample Weights grams.	Per Cent.	Per Cent Cumulative Weights	Analysis % MoS_2.	Content grams.	% of MoS_2 Values.	Cumulative % of MoS_2 Values.
....	1·050	26·67	.	·149	....	....	....	....	....	....	....
....	·742	18·85	....	·135	....	....	....	....	....	....	....
....	·525	13·33	....	·105	....	....	....	....	....	....	....
....	·371	9·423	....	·092	....	....	....	....	....	....	....
....	·263	6·680	3	·070	....	....	....	....	....	....	....
....	·185	4·699	4	·065	....	....	....	....	....	....	....
....	·131	3·327	6	·036	....	....	....	....	....	....	....
All these	·093	2·362	8	·032	....	....	....	....	....	....	....
....	·065	1·651	10	·035	....	....	....	....	....	....	....
....	·046	1·168	14	·025	32	1·2	1·2	1·12	0·60	2·8	2·8
....	·0328	·833	20	·0172	22	0·9	2·1				
....	·0232	·589	28	·0125	280	10·9	13·0	1·12	3·14	14·5	17·3
....	·0164	·417	35	·0122	506	19·8	32·8	0·97	4·91	22·6	39·9
....	·0116	·295	48	·0092	487	19·0	51·8	0·86	4·19	19·3	59·2
....	·0082	·208	65	·0072	398	15·6	67·4	0·84	3·34	15·4	74·6
....	·0058	·147	100	·0042	374	14·6	82·0	0·66	5·50	25·4	25·4
....	·0041	·104	150	·0026	200	7·8	89·8				
....	·0029	·074	200	·0021	116	4·6	94·4				
Pass	·0029	·074	200	·0021	144	5·6	5·6				
Totals	....	....	...	....	2559	100·0	....	0·85	21·68	100·0	....

Diagram IX.

Weight of tailing used for each test—1,000 grams.

Oil mixture in each case—½ pound pine oil and 1 pound

Test No.	Treatment of Tailing before Concentration.	Mesh ground to.	Concentrates.				Middlings.				Tailings.				Total Recovery figuring 70% of values in Middlings Recovered.
			Weight grams.	Analyses MoS_2.	Content MoS_2.	Per cent MoS_2.	Weight.	Analyses MoS_2.	Content MoS_2.	Per cent MoS_2.	Weight.	Analyses MoS_2.	Content MoS_2.	Per cent of MoS_2.	
			Grams.	%	Grams.	Values.	Grams.	%	Grams.	Values.	Grams.	%	Grams.	Values.	
1	Unwashed tailing..................	48	5·8	71·07	4·12	48·2	217	1·08	2·34	27·4	772·2	0·27	2·08	21·4	67·4
2	Unwashed tailing	65	5·0	61·08	3·05	37·2	223	1·41	3·14	38·3	772·0	0·26	2·01	24·5	64·0
3	Washed 15 min., decanted, dried and ground	48	3·5	85·53	2·99	37·9	163	1·79	2·92	36·9	833·5	0·24	2·00	25·3	63·7
4	Washed 15 min., decanted, dried and ground.........................	48	5·6	86·70	4·80	58·9	191	1·62	3·09	37·5	803·4	0·16	1·29	15·6	85·1
5	Same as No. 4, but ground to.. ..	65	4·6	65·60	3·02	37·1	202	1·47	2·97	36·5	793·4	0·27	2·14	26·4	62·6
6	3 washings of 15 mins. each, decanting after each wash, finally dried and ground to.........	48	12·7	33·80	4·29	43·5	193	1·16	2·24	22·7	791·3	0·42	3·34	33·8	59·4
7	Same as No. 6, but ground to.......	65	6·7	38·16	2·56	32·2	304	1·02	3·10	39·1	689·3	0·33	2·27	28·7	59·6

Test No. 98.

Two shipments of titaniferous iron ore were received, one on March 21, 1918, and the other on March 26, 1918, from Dr. Goodwin, Kingston, Ont.

No. 1 shipment..	2 bags.
Gross weight..	125 pounds.
Analysis—Fe..	46·23 per cent.
TiO_2..	27·56 "
No. 2 shipment..	2 bags.
Gross weight..	150 pounds.
Analysis—Fe..	46·63 per cent.
TiO_2..	28·51 "

Test work was conducted on these two lots to make a separation of the iron from the titanium. The results obtained were not promising, showing that it is not possible to effect a separation by mechanical means of ore dressing. The results are given in the following tables:—

Test No. I.—Separation by means of a horse-shoe magnet, with sheath on, under water.

Mesh.	Wt. of ore taken. Grams.	Product.	Wt. of products. Grams.	Analysis. % Fe.	% TiO_2
20	2,000	Magnetic	790	50·05	24·40
		Non-magnetic	186	32·29	40·15
38	1,000	Magnetic	154	50·45	24·20
		Non-magnetic	47	31·86	39·75
80	1,000	Magnetic	161	49·60	25·20
		Non-magnetic	38	33·05	38·35
150	1,000	Magnetic	159	49·38	32·08
		Non-magnetic	41	25·22	35·80

Test No. II.—Separation by water concentration on sand table after crushing to 30 mesh.

Product.	Weight. Lbs.	Analysis. % Fe.	% TiO_2
Concentrate	82·0	46·30	29·67
Middling	16·0	42·26	24·20
Tailing	4·0	35·79	24·00

Test No. III.—Magnetic separation (wet) on the Ullrich magnetic separator—after crushing to 35 mesh.

Product.	Weight. Lbs.	Analysis. % Fe.	% TiO_2
Ring No. 1	27·5	50·95	22·93
" 2	5·5	50·35	23·44
" 3	2·0	48·22	27·65
" 4	6·5	29·72	44·24
Middling	0·5	31·44	35·36
Tailing	4·0	30·43	34·75

Test No. 99.

On July 15, 1918, a shipment of molybdenite ore was received from the Wood Molybdenite Company, Ottawa, Ont. This shipment was from Masham, Que., and consisted of 18 cans:—

Gross weight	2,085·5 pounds.
Net weight	1,968·5 "
Analysis—MoS_2	1·97 per cent.
Content—MoS_2	38·78 pounds.

The molybdenite in the ore was of the flake variety in a heavy sulphide gangue of pyrrhotite and iron pyrites with a little pyroxenite. The ore for the most part was pure sulphides. Traces of arsenic are present.

Tests were conducted on the laboratory flotation machines to determine the adaptability of the ore for concentration by oil flotation.

The results of the test work are contained in the following table:—

Test No.	Machine Used.	Weight of Ore taken.	Oil Mixture.		Mesh Ore Crushed to.	Concentrates.			
			Pine Oil per ton.	Coal Oil per ton.		Weight.	Analysis content, percentage of Values.		
		Grams.	Lbs.	Lbs.		Grams.	% MoS_2.	Grams. MoS_2.	MoS_2.
1	Callow.	1,000	½	1	48	9·0	81·50	7·34	41·9
2	Janney.	1,000	½	1	48	24·0	23·86	5·73	33·6
3	Callow.	1,000	1	2	48	7·5	67·69	5·08	28·8
4	Callow.	1,000	1	2	65	11·0	53·13	5·84	35·8

Middlings.				Tailings.				Total Recovery figuring 70 % of MoS_2 in Middling Recovered.
Weight.	Analysis content, percentage of Values.			Weight.	Analysis content, percentage of Values.			
Grams.	MoS_2.	Grams. MoS_2.	MoS_2.	Grams.	% MoS_2.	Grams. MoS_2.	MoS_2.	
94	5·93	5·57	31·9	897	0·51	4·57	26·2	64·2
183	4·49	8·22	48·3	793	0·39	3·09	18·1	67·4
178	4·93	8·78	49·6	814·5	0·47	0·47	21·6	63·5
186	3·69	6·86	42·1	803	0·45	3·61	22·1	65·3

Conclusions.—Flotation results on this ore are not satisfactory. Tailings look clean with the naked eye but on examination under the microscope contain molybdenite included in the pyrites. Fine crushing does not seem to assist the concentration to any appreciable extent as shown in No. 4 test.

Test No. 100.

A shipment of 25 pounds in one box containing manganese ore samples was received on September 6, 1918, from O. Turgeon, M.P., Bathurst, N.B.

On examination the ore was found to be pyrolusite, finely crystalline in a gangue of quartz and reddish slate or shale.

The samples were crushed together to 50 mesh and sampled for analysis:—

Analysis—Manganese—Mn	23·27 per cent.
Iron—Fe	5·11 "
Silica—SiO_2	53·03 "

A concentration test was made on a small scale to determine the adaptability of the ore to concentration.

Five thousand grams of the ore crushed to pass 50 mesh were taken and run over a laboratory Wilfley table, the concentration products from which were weighed and sampled for analysis. The results of this test were as follows:—

Concentrate obtained	1,566 grams.
Analysis—Mn	53·13 per cent.
Fe	3·06 "
SiO_2	6·10 "
Content—Mn	832·02 grams.
Percentage of Mn. values	71·5 per cent.
Middling obtained	85 grams.
Analysis—Mn	35·41 per cent.
Fe	6·76 "
SiO_2	30·54 "
Content—Mn	30·10 grams.
Percentage of Mn. values	2·6 per cent.
Tailing obtained	2,319 grams.
Analysis—Mn	8·58 per cent.
Fe	3·18 "
SiO_2	79·91 "
Content—Mn	198·97 grams.
Percentage of Mn. values	17·1 per cent.
Slime loss	1,030 grams.
Analysis—Mn	9·94 per cent.
Content—Mn	102·42 grams.
Percentage of Mn. values	8·8 per cent.

Conclusions.—It will be noted from the above results that a concentrate was obtained of a grade 53·13 per cent manganese with a recovery of 71·5 per cent of the manganese values, and that a middling product was made of grade 35·41 per cent manganese representing 2·6 per cent of the manganese values in the ore. The tailing and slime loss combined represented 25·9 per cent of the manganese values in the ore.

The above results are exceptionally good for a manganese ore. The ore, however, is a fairly high grade one, and the recovery obtained would drop in proportion to the grade of the ore, that is on an ore of this class of grade 15 per cent manganese a recovery of 50 per cent of the manganese values would be the most that would be expected.

The concentrate obtained is a chemical product as the iron and silica are below the limit. Should the grade of the ore be around 15 per cent manganese, it would hardly be feasible in practice to make this high grade product, or at least any quantity of it, but a metallurgical product could be made of grade 45 per cent to 48 per cent that could be used for reduction to ferro-manganese.

Test No. 101.

A shipment of scheelite ore was received on August 28 from Geo. A. Cameron, Eureka, N.S.

This shipment was contained in 21 canvas sacks.

Gross weight	1,075 pounds.
Net weight	1,067 "
Sample weights	4 "
Net weight treated	1,063 "

Analysis—WO_3	40·47 per cent.
As	6·06 "
MoS_2	Nil.
Au	Nil.
Ag	Nil.
Pt	Nil.
Content — WO_3	430·1961 pounds.
As	32·5278 "

The scheelite occurs in a quartz gangue, associated with it is a small amount of pyrite and arsenopyrite.

Tests were conducted on this ore to obtain a commercial product, suitable for reduction to ferro-tungsten in an electric furnace.

The ore was crushed to pass 20 mesh and sampled. It was then run over a concentrating table, the middling from the table being reground to 50 mesh and run over the table. The result of this concentration was as follows:—

Concentrate—Weight	644·5 pounds.
Analysis—WO_3	64·73 per cent.
As	4·18 "
Content—WO_3	417·1848 pounds.
As	26·94 "
Percentage of WO_3 values	96·98 per cent.
Tailing—Weight	295 pounds.
Analysis—WO_3	1·10 per cent.
Content—WO_3	2·849 pounds.
Percentage of WO_3 values	0·66 per cent.
Slime loss—Weight	50·5 pounds.
Analysis—WO_3	17·08 per cent.
Content—WO_3	10·1623 pounds.
Percentage of WO_3 values	2·36 per cent.

Conclusions.—From the above ore, a concentrate of grade 64·73% was obtained with a recovery of practically 97 per cent of the WO_3 values; 3 per cent of the WO_3 values was lost in slime and in the tailing.

The concentrate obtained carries 4·18 per cent As. in the form of arsenopyrite. This will necessitate roasting of the concentrate to eliminate the arsenic in order to obtain a first-class product.

Test No. 102.

GRAPHITE ORE FROM LACHUTE, QUE.

A shipment of graphite ore of approximately 300 pounds was received on October 9, from Thos. H. Rae, Lachute, Que.

On examination it was found that the flake was fairly fine. The gangue material was composed of quartz and crystalline limestone. A small amount of iron pyrites is present.

The ore was crushed to 30 mesh and sampled giving an analysis of carbon 15·00 per cent.

A series of tests were made on the Callow pneumatic testing machine to determine its adaptability to concentration by this method.

For this purpose a portion was crushed in a small ball mill to pass 40 mesh, while another portion was crushed to 30 mesh. It was found that it would be necessary to crush to a fineness of 30 mesh to free the flake from the gangue.

The results of the test work are contained in the following table:—

				Concentrates.											
———				+ 80 0·175 mm.				−80+115.				−115 0·124 mm.			
Run No.	Wt. of Ore taken. Grams.	Analysis % C.	Content Grams C.	Wt. Grams.	Analysis % C.	Content Grams C.	% of C. Values.	Wt. Grams.	Analysis % C.	Content Grams C.	% of C. Values.	Wt. Grams.	Analysis % C.	Content Grams C.	% of C. Values.
1.	3000	15·0	450	96	92·00	88·32	19·5	189	64·52	121·94	26·9	518	44·60	231·03	51·0
2.	2000	15·0	300	63	93·80	59·09	18·4	81	88·85	71·97	22·4	336	53·60	180·10	55·9
3.	2000	15·0	300	72	90·80	65·38	21·8	109	60·23	65·65	21·9	338	48·00	162·24	54·1
4.	1000	15·0	150	97	62·00	60·14	40·1	97	46·30	44·91	30·0	118	33·30	39·29	26·2
5.	1000	15·0	150	36	94·40	33·98	22·1	38	93·70	35·61	23·2	94	82·30	77·36	50·4
6.	1000	15·0	150	58	89·50	51·91	34·7	38	84·40	32·07	21·4	115	50·45	58·02	38·7

		Middlings.				Tailings.				
Total of C.	Recovery Values.	Wt. of Grams.	Analysis % C.	Content Grams C.	% of C. Values.	Wt. of Grams.	Analysis % C.	Content Grams. C.	% of C. Values.	Total % of C. Values in Middlings and Tailings.
97·4	....	557	1·58	8·80	1·9	1640	0·20	3·28	0·7	2·6
96·7	....	451	1·70	7·67	2·4	1069	0·28	2·99	0·9	3·3
97·8	....	331	1·20	3·97	1·3	1150	0·24	2·76	0·9	2·2
96·3	....	195	2·40	4·68	3·1	493	0·18	0·89	0·6	3·7
95·7	....	173	2·95	5·10	3·3	659	0·23	1·52	1·0	4·3
94·8	....	296	2·30	6·81	4·6	493	0·18	0·89	0·6	5·2

Run No. 1.—Ore was first crushed to 40 mesh; pine oil and coal oil used; ground for 5 minutes in pebble mill; floated; concentrates reground for 15 minutes in pebble mill and floated.

Run No. 2.—Ore was first crushed to 40 mesh; pine oil and coal oil used; ground for 5 minutes in pebble mill; floated; concentrates reground for 20 minutes in pebble mill and floated, resulting in a higher grade concentrate on all sizes than Run No. 1 but with a little lower recovery of carbon values in high grade flake.

Run No. 3.—Ore was first crushed to 40 mesh; pine oil and coal oil used; ground for 5 minutes in pebble mill; floated, concentrates reground for 10 minutes in pebble mill and floated, resulting in a little lower grade concentrate than No. 1 run on the coarser sizes but a little higher recovery of carbon in high grade flake.

Run No. 4.—Ore was first crushed to 30 mesh; a small amount of No. 25 F.P.L. light creosote oil used; ground for two minutes in pebble jar to get oil mixed; floated; concentrates refloated without further grinding; results in a low grade concentrate with a high recovery of carbon values on the coarser sizes. This test was run to see what the results would be without regrinding.

Run No. 5.—Ore was first crushed to 30 mesh; a small amount of No. 25 F.P.L. light creosote oil used; ground for five minutes in a pebble jar; floated; concentrates reground for twenty minutes in pebble jar and floated; resulting in a very high grade concentrate on all sizes with a high recovery of the carbon values.

Run No. 6.—Ore was first crushed to 30 mesh; a small amount of No. 25 F.P.L. light creosote oil used; ground for five minutes in a pebble jar; floated; concentrates reground for ten minutes in pebble jar and floated, resulting in a lower grade concentrate than run No. 5 but with a much higher recovery of the carbon values in the coarser sizes.

This series of tests were run to make as high grade a concentrate as possible and to hold as much as possible on the coarser sizes.

Summary.—The ore is readily adaptable to the oil flotation process. The results of the above test show that 95 per cent of the carbon values is recovered in the concentrates; that with proper manipulation 20 per cent to 25 per cent of the carbon values is contained in the flake on 0·175 mm. screen of a grade above 90 per cent, and 20 per cent to 25 per cent of the carbon values is contained in the flake through 0·175 mm. screen and on 0·124 mm. screen of a grade around 90 per cent and 45 per cent to 50 per cent of the carbon values is contained in flake through 0·125 mm. screen of a grade above 80 per cent.

The consumption of oil is very small, ranging between one pound and two pounds per ton of ore.

The flake in this ore is a very thin and high grade one, which floats readily with the addition of very little oil.

Test No. 103.

A shipment of 50 pounds of graphite ore was received on October 10, 1918, from the Jas. H. Mason Smelting Co., Toronto, Ont.

The graphite in this ore was fairly coarse flake in a gangue of quartz and crystalline limestone.

The ore was crushed to 30 mesh and sampled, giving an analysis of 2·37 per cent carbon.

Tests were made on the Callow pneumatic testing machine to determine its adaptability to concentration.

Run No. 1.—Made on 4,000 grams of the ore. Ground in a pebble jar for 5 minutes with a small amount of pine oil and coal oil. Floated in testing machine; the concentrates reground for 10 minutes in the pebble jar and refloated.

Concentrate+80-mesh	26 grams.
Analysis—C	87·65 per cent.
Content—C	22·79 grams.
Recovery of C. values	26·2 per cent.
Concentrate—80+115-mesh	31 grams.
Analysis—C	66·60 per cent.
Content—C	20·65 grams.
Recovery of C. values	23·8 per cent.
Concentrate—115-mesh	58 grams.
Analysis—C	65·45 per cent.
Content—C	37·86 grams.
Recovery of C. values	43·6 per cent.
Middling	44 grams.
Analysis—C	3·00 per cent.
Content—C	1·32 grams.
Percentage of C. values	1·6 per cent.
Tailing	3,841 grams.
Analysis—C	0·11 per cent.
Content—C	4·23 grams.
Percentage of C. values	4·8 per cent.
Total recovery in concentrate	93·6 "
Percentage of carbon values in middling and tailing	6·4 "

Run No. 2.—Made on 2,000 grams of the ore. Ground in pebble jar for 5 minutes with a small amount of pine oil and coal oil. Floated in testing machine and the concentrates reground for 5 minutes in the pebble jar and refloated.

Concentrate +80-mesh	32 grams.
Analysis—C	82·70 per cent.
Content—C	26·46 grams.
Recovery of C. values	50·4 per cent.
Concentrate—80+115-mesh	12 grams.
Analysis—C	74·50 per cent.
Content—C	8·94 grams.
Recovery of C. values	17·0 per cent.
Concentrate—115-mesh	21 grams.
Analysis—C	69·00 per cent.
Content—C	14·49 grams.
Recovery of C. values	27·6 per cent.
Middling	60 grams.
Analysis—C	1·80 per cent.
Content—C	1·08 grams.
Percentage of C. values	2·1 per cent.
Tailing	1,875 grams.
Analysis—C	0·08 per cent.
Content—C	1·50 grams.
Percentage of C. values	2·9 per cent.
Total recovery in concentrate	95·0 "
Percentage of carbon values in middling and tailing	5·0 "

Summary.—The ore is adaptable to concentration by the oil flotation process. A recovery of 95 per cent of the carbon values can be obtained in concentrates. A 90 per cent carbon flake should be obtained on the coarser sizes with a 65 per cent to 70 per cent grade in the fines. It is a question of manipulating the crushing to obtain this. The low content of graphite in the ore would not make it a commercial proposition.

Test No. 104.

A shipment of placer scheelite concentrates was received on August 13, 1918, from D. E. Clindinin, Dawson, Y.T. This shipment consisted of 10 bags having a gross weight of 1,301 pounds and a net weight of 1,293 pounds.

A sample was cut out by means of the Jones riffler sampler for analysis.

Net weight received	1,293 pounds.
Analysis—WO_3	66·50 per cent.
Au	8·30 oz.
Ag	1·20 "
Content — WO_3	859·845 pounds.
Au	5·367 oz.
Ag	0·776 "

The concentrate was crushed to pass a 40-mesh screen in rolls and the metallics caught on the screen. These metallics contained the coarse gold and represented approximately 55% of the gold values. They were melted down into bullion.

Weight of metallics	150 grams.
Weight of bullion obtained	3·12 oz.

The concentrate through 40-mesh was sampled, weighed, and packed for shipment as follows:—

Gross weight	1,300 pounds.
Net weight	1,285 "
Analysis—WO_3	66·90 per cent.
Au	3·30 oz.
Ag	0·18 "
Content — WO_3	859·665 pounds.
Au	2·12 oz.
Ag	0·115 "

Amalgamation and cyanide tests were made on samples of the concentrate through 40 mesh. The results of the amalgamation tests were as follows:—

Assay before amalgamation—Au	3·30 oz.
Ag	0·18 "
Assay after amalgamation—Au	0·21 "
Ag	0·03 "
Extraction of gold values	90·6 per cent.
Extraction of silver values	83·3 "

Cyanide tests were made on samples of the concentrates, crushed to 40 mesh and crushed to 100 mesh but gave poor results. The tests made on the concentrate without washing showed an extraction of 50% of gold and silver values with a very high consumption of cyanide; on the washed concentrate, the extraction was 20% of the gold values on the 40-mesh material and 60% on the 100-mesh material with a low consumption of cyanide.

Conclusions.—From the above tests it was found that the gold and silver values in the concentrate was in the form of coarse flake, 55% of which could be caught as metallics in crushing to 40 mesh and 90% of the remaining gold values and 83% of the remaining silver values could be recovered by amalgamation.

III

REPORT OF THE CHEMICAL LABORATORY.

H. C. Mabee, *Chemist.*

Owing to the continued demand by munition authorities for molybdenum, the sampling and chemical examination of molybdenite ores and concentrates carried on during the previous year, was continued during the early part of 1918, as also the sampling and analysing of ferro-molybdenum and other ferro alloys.

During the year, a large number of field samples of ores and minerals were received through the Canadian Mineral Resources Commission from various localities throughout the Dominion. As many of these samples required a more or less complete analysis, a great part of the time of the chemical staff was occupied with this class of work. At the close of the year, some 125 samples of gold-platinum sands were received through the Commission from the Tulameen river, Potato creek, and other districts in British Columbia. The assay results of these samples were not completed at the close of the year and are therefore not included in this report.

In the Ore Dressing and Metallurgical Laboratories a large number of experimental tests were performed during the year, which also involved the usual amount of samples and chemical analyses.

The total number of samples submitted for analysis was 1,240. These may be conveniently arranged according to the following classification, with, for the most part, the nature of the chemical analysis performed in each case.

Barite, 1 sample.

Determined—barium sulphate, silica, nickel, and cobalt.

Chromite, 2 samples,

Determined—chromic oxide, copper, nickel, and cobalt.

Copper, 21 samples.

Determined—copper, silver, gold, lead, and zinc.

Ferro-manganese, 15 samples.

Determined—manganese, iron, silica, phosphorus, and sulphur.

Ferro-manganese slags, 14 samples.
Determined—manganese, iron, silica, and lime.

Ferro-molybdenum, 22 samples.
Determined—molybdenum, carbon, and sulphur.

Graphite, 58 samples.
Determined—carbon, silica, and iron.

Gold, 42 samples.
Determined—gold, and silver.

Gold-cobalt, 80 samples.
Determined—gold, cobalt, molybdenum, nickel, and arsenic.

Iron, 7 samples.
Determined—iron, silica, lime, phosphorus, and sulphur.

Manganese, 200 samples.
Determined—manganese, iron, silica, phosphorus, and sulphur.

Molybdenite, 619 samples.
Determined—molybdenum sulphide, and molybdenum tri-oxide.

Nickel, copper ores and slags, 8 samples.
Determined—nickel, copper, iron, silica, and sulphur.

Pyrite, 21 samples.
Determined—sulphur, arsenic, lead, zinc, and copper.

Platinum, gold, 59 samples.
Determined—platinum, and gold.

Sandstone and gravel, 6 samples.
Determined—silica, iron, and lime.

Steel, 2 samples.
Determined—carbon, manganese, sulphur, and phosphorus.

Tungsten, 26 samples.
Determined—tungstic acid, arsenic, copper, and gold.

Titaniferous iron, 28 samples.
Determined—titanic acid, and iron.

Zinc-lead, 9 samples.
Determined—zinc, lead, and iron.

Out of the total number of samples analysed, about 310 were directly or indirectly for the Canadian Munitions Resources Commission, 40 for the Imperial Munitions Board, and 890 from customs work and experimental tests performed in the Ore Dressing Laboratories.

CERAMIC DIVISION.

J. Keele, *Chief of the Division.*

Introductory.

The laboratory work during the last year consisted of testing materials sent in for examination and in special experimental work on magnesite, dolomite, and silica, for refractory uses.

The areas of brick clay in the Ottawa valley between Arnprior and Pembroke were partly mapped and sampled during the field season and about two weeks prospecting for tile clay was done in Prince Edward Island by the writer.

There is an increasing demand for information regarding clay deposits suitable for the manufacture of structural materials in order to meet the needs in building. As several of the brick plants in Canada were either closed during the last few years or operating under a partial output, it is not probable that many new plants will be started, but changes which make for increased efficiency in handling material and in the saving of fuel are likely to be largely adopted in most of the plants now in operation. The increasing cost of fuel will be a powerful incentive to prevent waste in firing clay wares.

The annual value of clay products made in Canada, also the amount of imported clay products, are given in the Mineral Production of Canada. This is a statistical report which is published annually by the Mines Branch.

A report on silica in eastern Canada is in preparation; this report will include those forms of quartz suitable for ceramic processes.

The position of assistant Ceramic Engineer has not been filled up to the present, consequently the work undertaken by the Division is limited. There are no facilities offered in training in this branch of engineering in Canada.

The following pages include some of the more important tests on clays made during the year. The record of the majority of the tests is not included, as many samples reach us which are not accompanied by any adequate description, either of exact locality or amount available, hence the determinations are of dubious value to the general reader.

BRITISH COLUMBIA.

Residual Clays.

Residual clays are the result of certain processes which break down the structure of rocks and soften them in situ. Weathering and leaching by surface and ground waters appear to be the most active agencies in the formation of residual clays, but this alteration has in some cases been effected by pneumatolysis, which is the action of heated, chemically active gases ascending from below.

The principal rocks yielding residual clay are granites, felsites, porphyrites, basalts, tuffs, slates, argillaceous quartzites, or sandstones, and impure limestones.

The residual clay most highly valued in the industries is kaolin or china-clay. This material is white in colour both in the raw and burned state and is highly refractory, resisting the action of heat up to the softening point of cone 34 (1810 deg. C.). The chemical analysis of such a clay yields little more than silica, alumina.

and water. When iron, lime, magnesia, titanium, and alkalis, which are fluxing impurities, show in any appreciable quantity in an analysis the material begins to deteriorate in value, and although a clay with as high as 7 or 8 per cent of these impurities may be refractory and might be used as a fireclay, it would not be a kaolin in the industrial sense.

The principal users of kaolin or china-clay are the paper makers and potters, but it has many minor uses.

Whiteness in colour, fineness in grain, and refractoriness are the essential qualities required for these uses. Clays which appear pink or reddish-yellow or grey in colour in the field may be useful in some branch of the clayworking industry but not in those where whiteness in colour is imperative. The varied colours of the raw clays are mostly due to the iron content and these colours are generally intensified on burning.

Residual clays are comparatively rare in British Columbia as they are in most glaciated regions, but in the Interior Plateau region where glaciation seemed to have been less severe than in other portions of the Province a few occurrences have been noted.

While residual clays strictly speaking are those which have not been moved from their original position, some of these clays are accumulated in a flat at the foot of the rock slopes from which they were derived, but if their origin is apparent they may still be regarded as residual deposits.

Prospecting for kaolin has been taken up in recent years in British Columbia, but so far no deposit of commercial value has been recorded. A few occurrences of material approaching kaolin in character but of small extent are included in the following notes.

DUCKS.

About 4 miles southwest of Ducks a clay deposit occurs between two small lakes known as the Buce lakes. Samples were collected from this deposit in 1918 by W. F. Ferrier, who describes the occurrence as follows: "The clay is deposited in a flat at the base of a hill with steep jugged peaks, and is evidently derived from the alteration of the rocks of which the hill is composed.

In the upper part are rusty weathering, black diabase, with some included tuff beds. Below these is a pale coloured and rusty weathering phase of the diabase, very highly altered, with feldspar almost entirely kaolinized. Lower down the hill the rock becomes darker in colour. The thickness of the soil covering the clay varies from practically nil to about a foot. The average thickness of the clay is not more than 24 inches, varying from a few inches to about 30 inches. It is somewhat sandy on top, passing into plastic clay practically free from gritty particles. It is usually underlain by about 2 inches of pinkish sandy clay, beneath which is sand or gravel composed of particles of rock from the hillside.

The clay is of a light buff colour when first exposed, but is chalky white when dried. A black stain, probably of peaty matter runs through it in places.

The amount of clay present is altogether too small to be of economic importance, but the occurrence is recorded on account of the unusual character of portions of the deposit.

Four samples were collected by Dr. Ferrier and sent to the clay testing laboratory where the following results were obtained.

Lab. No. 635, Kerr Sample No. 1. Soft grey clay with good plasticity, fairly smooth in texture.

It dries very slowly with a shrinkage of 6 per cent.

This clay burns to a cream-coloured, porous body, and even when heated to 1270 deg. C. (the softening point of cone 7), its absorption is 32 per cent. The fire shrinkage is large being 10 per cent, or the total shrinkage 16 per cent.

This clay fuses about 1570 deg. C. (the softening point of cone 20), so that it is only semi-refractory, and is not a fireclay.

On account of its high shrinkage and its refusal to become dense at cone 7 (the general temperature of burning stoneware pottery), this clay cannot be used alone for pottery manufacture but might be used as a bonding clay in a mixture.

Lab. No. 636. Kerr Sample No. 2. Soft white, chalky clay with some darker grey particles.

This clay is very short in texture when wet. Its plasticity is so low that it was difficult to mould into test pieces. It dries readily after moulding, the shrinkage on drying being about 4 per cent.

This clay burns to a white chalky body of no strength at the lower temperatures.

When burned to cone 5 (1230 deg. C.), the shrinkage is abnormal and the body is still porous.

This clay is not fused when heated up to the softening point of cone 30 (1730 deg. C.), so that it is a highly refractory material.

Lab. No. 637. Kerr Sample No. 3. Soft white, chalky clay containing some rock particles.

This clay has very little plasticity when wet so that it is difficult to mould.

It forms a very weak, porous, white body when burned at low temperatures. When burned to cone 5 its shrinkage is 22 per cent which is excessive. The colour is cream, with brown specks.

This clay is similar in properties to 636.

Lab No. 638. Sample taken from Alkali pond on Mr. Tait's property. This is a greenish-grey clay, highly plastic, smooth and pasty when wet, and is stiff and hard to work.

It dries very slowly, the moulded shapes have a tendency to crack on drying and it burns to a dense strong body at low temperatures.

This clay could probably be used for the manufacture of common red building brick, but would require the addition of sand in order to overcome its drying defects and reduce the shrinkage.

Mixture of Clays.

A mixture of equal parts of each of the above clays was moulded and burned up to the softening point of cone 5. At this temperature the mixture forms a strong dense body of mottled buff colour like a fire brick in appearance, but with an excessive shrinkage.

If the shrinkage should be overcome the mixture would make a low grade of semi-refractory brick for local use, as it is unaffected when raised to the temperature of 1550 deg. C.

Samples Nos. 636 and 637 resemble kaolin in character inasmuch as these clays are fairly white and of low plasticity in the raw state and retain a nearly white colour when burned. The clay was only tested to a temperature of cone 30, but will probably go somewhat higher before softening. Their defects are lack of plasticity, excessive shrinkage and slight discoloration. As all kaolins must be washed before becoming commercial products, the washing process would probably improve the above clays if the quantity in the deposit was large enough to warrant that operation.

BONAPARTE VALLEY.

About 17 miles north of Ashcroft in the Bonaparte valley are extensive occurrences of residual clay. They extend upwards for several hundred feet from the level of the river and the Cariboo road on the west side of the valley, and consist of alternate bands of light yellow to brown-red clay of rather unusual appearance. Across the river are similar bands and they are also found farther to the north in the valley with occasional bands of nearly black colour accompanying the yellow and red clays.

Samples of these clays were collected by L. Reinecke of the Geological Survey from two beds lying above and west of the road at a point about 17½ miles from Ashcroft, near several abandoned mine tunnels.

The rocks here consist of very fine-grained grey quartzite and white coarse-grained quartzite. The clay area is half a mile or so in length and several hundred yards in width measured down the slope. The depth to which weathering has penetrated was ascertained in one of the mine tunnels where most of the material was turned to clay to a distance of 30 feet from the surface before solid rock was encountered.

It is impossible to select samples of clay that do not contain from 30 to 50 per cent of rock fragments, so that the material as a whole must be ground for use or else the clay portion of the deposit would have to be separated from the rock by a washing and settling process.

These clays proved on testing to be short in texture and of low plasticity. They burn to strong red colours and begin to soften at comparatively low temperature. Even if these clays were free from the rock fragments they would have little value in the clayworking industry.

CHIMNEY CREEK, LILLOOET.

An outcrop of whitish clays occurs on the west side of the valley of the Fraser river near Chimney Creek bridge. This deposit was examined by Mr. L. Reinecke in 1918, who states that the clays are residual from argillaceous quartzites of the Cache Creek series. The quartzite beds are broken and folded at this point, and a patch about 400 feet long and 300 feet wide is partly kaolinized. Four samples representing different portions of the outcrop were collected and sent to the laboratory of the Mines Branch for testing.

Lab. No. 650. Whitish residual clay containing many fresh or slightly altered quartzite particles. A portion of this sample was ground to pass a 16-mesh screen. It had only a low plasticity when wet, but was easily moulded into shape.

This clay burns to a dark grey, hard body at cone 5 (1230°C) the shrinkage is not very great and the absorption was 6 per cent.

A portion of the clay washed and screened through an 80-mesh screen yielded about 50 per cent of plastic clay, the remainder being sand and rock fragments. The washed clay is plastic and burns to a hard light grey body, resembling a stoneware clay in character.

The crude clay fuses at cone 18 (1490°C.) and the washed clay is fused at about cone 15 (1430°C.), so that the material is only semi-refractory and not a fireclay.

Lab. No. 651. White and pink residual clay. This material was ground to pass a 16-mesh screen. Its plasticity was low when wetted and many of the coarse particles did not slake down so that the clay was granular in texture.

This clay burns to a cream-coloured body at cone 5 with a total shrinkage of 15 per cent and an absorption of 17 per cent. The shrinkages of this clay are too great. A portion of the clay was ground in a ball mill until fine enough to pass an 80-mesh

screen when it had fairly good plasticity and was smooth when wetted. Some floor tile samples were made up by the dry process from the ground clay. These tile when burned to cone 5 were slightly off the white colour and were not vitrified, but would probably become vitrified at a slightly higher temperature. This clay makes up into a good casting slip for pouring wares in plaster moulds, but as the shrinkage is excessive it would require the addition of potters flint.

This clay is not affected when heated up to the softening point of cone 30 (1730°C.) and as it may stand a higher temperature than this before softening, the material may be regarded as a high grade of fireclay.

Lab. No. 652. Mottled white and pink, hard clay. This material had a low plasticity when ground and mixed with water.

It burns to a hard buff coloured body at cone 5, with a total shrinkage of 11 per cent and an absorption of 11 per cent.

This sample is not so refractory as 651 as it begins to soften at cone 26 (1650°C.) but it will pass as a fireclay.

Lab. No. 655. Light buff coloured residual clay, hard and only partly kaolinized. This material was ground in a ball mill to pass a 150-mesh screen. In this finely divided condition it had fair plasticity, but was rather short in texture. The material burns to a dark grey vitrified body at cone 5 with a total shrinkage of 14 per cent.

The sample fuses to a slag at cone 18, so that it is only semi-refractory.

These tests show that the deposit is uneven in quality, that the clay forming processes are not completed, as plasticity is generally low and fluxing impurities are rather high in certain portions.

The clays of this deposit as a whole might be worked for the manufacture of a low grade of firebrick or as a mixture with a more plastic clay for making sewer pipe. If the material was crushed and washed it would yield a certain amount of fine clay which could be used in the manufacture of stoneware goods, but the yield of washed clay would probably be too small to repay that operation. As the material is not fine-grained and is not white either in the raw or burned state it cannot be classed as a commercial kaolin or china-clay. The deposit is 16 miles from the nearest point on the Pacific Great Eastern railway.

Brick Clays.

Stoneless glacial clays suitable for brickmaking occur in the valleys from the coast far into the interior along the principal rivers flowing into the Pacific. These clays are generally laminated and often interstratified with layers or beds of sands. They are referred to as the white silts in reports on the geology of the region, but their colours really vary from light grey to yellowish.

The silty clays in the Nicola valley and on the Fraser and Thompson rivers burn to a red colour but those on the upper Columbia valley along the Windermere lakes contain a very high percentage of lime and burn to a buff colour and porous chalky body. All the brick plants in British Columbia use these silty glacial clays in the manufacture of common brick. Clays of this description have been collected from a number of points and tested in the laboratory. Common brick made by the soft-mud process are as a rule the only class of clay product for which they are suitable —but at some localities, however, they are plastic enough to flow through a die smoothly, so that they can be made into field drain tile. Some of the highly plastic varieties may be difficult to dry and have an unduly large amount of shrinkage, but these defects can usually be overcome by the addition of a certain amount of sand.

None of these clays are suitable for the manufacture of vitrified wares as they soften and deform when overburned on account of their low fusibility.

The following samples have been received and the tests made on them subsequent to the publication of the preliminary reports on the clays of British Columbia.[1]

[1] Memoirs 24, 25, and 65, Geological Survey, Department of Mines.

Gordon Creek, Yale.—A sample of clay from Gordon creek was sent to the Mines Branch for examination by Mr. A. M. Herring, of New Westminster.

The sample was a massive grey clay, rather silty in character but free from pebbles or coarse grit. It is evidently from those stoneless glacial clays known as the White Silts.

When mixed with 30 per cent of water it has good plasticity and working qualities. It can be dried fairly rapidly without cracking, the shrinkage on drying being 6 per cent.

The clay burns to a porous but strong red body at temperatures from 1,750 to 1,850 degrees Fahr., but if fired at slightly higher temperatures the shrinkage becomes too great and deformation ensues.

This clay is suitable for the manufacture of common red building brick either by the soft-mud or wire-cut process. It would probably also be suitable for field drain tile. The addition of sand is not necessary as the shrinkages within the commercial limits of burning are not too high.

Lillooet district.—An outcrop of a fine, greenish-grey, bedded silt with a few sandy layers occurs on the wagon road to Seton Lake on the north side of Cayoosh creek, and about 1 mile from Lillooet. There is a shear cut bank of silt about 40 feet high and 400 feet long at this place. Eighteen feet of this was sampled, a few coarser layers of sand being omitted. The sample when wet and moulded into bricks showed an air shrinkage of 5 per cent. The shrinkage on burning is very small and the body remains quite porous even when burned to cone 03 (2,000 deg. F.). This silt makes a very fair common red building brick by the soft-mud process, but is not plastic enough for wire-cut brick or drain tile.

Samples of a similar silt from Sheppards ranch at Kersley on the Fraser, below Quesnel, yielded very nearly the same results.

Another sample of clay from the same district was collected by Mr. Charles Camsell, of the Geological Survey. This was a light grey, silty clay which occurs at the mouth of Owl creek, a tributary of the Birkenhead river. Owing to its silty character it does not work up into a very plastic body when ground and mixed with water, but is short in texture and rather flabby. It can be dried quickly after moulding without danger of cracking.

This clay burns to a light red, porous but strong body at a temperature of 1,800 degrees Fahr., with a total shrinkage of only 5 per cent. When burned to 1,900 the brick darken slightly in colour and become more dense in structure. The clay begins to soften at a temperature of 2,000 degrees F.

Good common red building brick can be made from this clay by the soft-mud process, and as the shrinkages are low it would not be necessary to add sand.

Ducks.—Along the valley of the South Thompson river conspicuous terraces have been cut in the silts for a distance of about 30 miles. A sample of this material collected by Professor R. A. Daly from the bluff a short distance below Ducks station, on the north side of the river, had the following chemical analysis, as determined by M. F. Connor, of the Mines Branch:—

Silica	67·38
Alumina	15·53
Iron	2·50
Lime	2·00
Magnesia	0·90
Soda	5·83
Potash	2·46
Titanium	0·40
Manganese	0·07
Water	3·70
	100·77

Although the 14 per cent of fluxing impurities present in this clay is not very high for a brick clay, the alkalis—soda and potash—are present in unusually large amounts and as these ingredients are very active fluxes the clay consequently will stand very little overfiring without softening.

A sample of this clay from the Monte Creek ranch, in the vicinity of Ducks, was submitted for testing by the Hon. Hewitt Bostock. This was a laminated clay, light grey in colour when dry. It required the large amount of 40 per cent of water to bring it to the best working consistency. It had good plasticity and smoothness, forming a perfect hollow round tile in the hand press.

It stands moderately fast drying without cracking, the drying shrinkage being high on account of the large quantity of water required for mixing.

The clay burns to a light red, hard body at 1,700 degrees F., and appears to make a good common brick at this temperature as far as strength and durability are concerned. As the shrinkage is unduly high even at this low temperature the addition of 25 to 35 per cent of sand would be desirable.

If the clay is burned to 1,850 degrees F. the shrinkage becomes abnormal, the colour bad and the test pieces were checked, warped, and vitrified.

The behaviour of this clay at such a low temperature can only be accounted for by the large percentage of the alkalis which it contains as shown by the foregoing chemical analysis. There is a marked contrast between the clay at Ducks and those at Lillooet, as the latter clays are only beginning to assume their best burned condition at a temperature which overfires the clay at Ducks.

Smithers.—A sample of clay was collected from the east bank of the Bulkley river, 300 yards south of the bridge at Smithers, by J. D. McKenzie, of the Geological Survey, and sent to the Mines Branch for testing.

This material is a stratified, grey, non-calcareous clay, which turns almost black when wet. It requires the large quantity of 40 per cent of water to bring it to the best working consistency. It is smooth and fine-grained and rather sticky but flows fairly well through a round tile die. The shrinkage on drying is 10 per cent, which is excessive.

The clay burns to a good hard red body at cone 010 (1,750 degrees Fahr.). If burned to a much higher temperature than this the shrinkage becomes too great. The clay is easily fusible and cannot be used in the manufacture of vitrified wares. Its uses are confined to the manufacture of common building brick or field drain tile, but it would require the addition of 20 to 30 per cent of sand in order to reduce the shrinkage.

A sample collected by J. J. O'Neill from the bank of the Bulkley river between Hazelton and Telkwa is practically the same kind of clay as that at Smithers.

Australia creek.—A seam of Tertiary clay about two feet thick underlies four and one-half feet of lignite, on the north side of Australia creek, about one mile or so from the Fraser. In a tunnel driven into the coal a sample of the clay was collected twenty feet from the tunnel mouth. This clay was fairly plastic, much more so than the glacial surface silts mentioned above. It shows a shrinkage on drying of 6 per cent and a further shrinkage of 6 per cent when burned to cone 06 (1,030° C.). This shale burns to a good hard brick of deep buff colour.

Because of the carbon present in this clay care should be taken to prevent a too rapid rise in temperature when burning, or bloating will ensue. This shale would require the addition of about 25 per cent of sand for brickmaking. It is not refractory.

Bentonite.

The variety of clay known as "bentonite" occurs at many localities in Wyoming, where it first attracted attention by its peculiar properties. Its position in the Benton formation of the Cretaceous suggested its name.

Bentonite when freshly exposed varies from a light yellow to a light olive green with a waxy lustre. In freshly uncovered outcrops it appears as a bedded joint clay, the blocks varying from roughly rectangular or conchoidal to long slender pieces. The joints are more or less open and occasionally contain crystals and plates of gypsum. The clay is exceedingly fine-grained and has a soapy feeling when wet. It swells and forms a jelly-like mass in an excess of water.

Uses.—Its chief use hitherto has been to give body and weight in the manufacture of paper, but another extensive use of the clay was as an adulterant in the manufacture of cheap candy. A patent preparation much used as a poultice and known as antiphlogiston is made by grinding bentonite in glycerine.

Recently the use of bentonite in the textile industry is suggested for the sizing of yarns. It is said to be valuable for this purpose on account of the large proportion of colloidal silicate of alumina which it contains.

The price obtained for bentonite in 1908 was $6 to $7 per ton f.o.b.

Occurrences in Canada.—Bentonite was first discovered in Canada in 1911 by Keele in an excavation in the town of Camrose,[1] Alberta, and later at other localities, notably in the Edmonton formation along the Red Deer river.

Ries describes an occurrence of bentonite on the Triangle ranch near Quilchena in the Nicola valley, British Columbia.[2]

Samples of material received from various sources in British Columbia proved on examination to be bentonite, but no description of extent of deposit or the exact locality of these occurrences was given. It is probable therefore that this material is not uncommon in British Columbia as well as in Alberta.

Although many of the samples examined had all the characteristics of bentonite they also contained a certain amount of mud or clay, and it is probable that this impurity would unfit them for most of the above uses.

Chemical Analyses of Bentonite.

——	Crook County, Wyoming*.	Camrose, Alberta**.
Silica	61·08	69·14
Alumina	17·12	14·50
Iron	3·17	2·56
Lime	2·69	2·45
Magnesia	1·82	1·14
Potash	....	19
Soda	·20	1·25
Sulphur trioxide	·80	1·70
Loss on ignition	12·10	7·71

*Wyoming Experimental station, Bull. 14, p. 193, 1893.
**Memoir 25, p. 89, Geological Survey, Dept. of Mines, Canada.

Origin of Bentonite.—Two samples of residual clays and of the parent rock from which they were derived were collected by Mr. Reinecke during the summer of 1917 near Seventeen Mile house on the Cariboo road in the valley of the Fraser river.

These clays had that sticky type of plasticity when wet and the moulded shapes made from them cracked badly while drying which is characteristic of clays containing bentonite. On mixing the clays in an excess of water and screening the coarse particles out a yellowish fine-grained residue was obtained on evaporation. This residue became gelatinous in water and had every appearance of bentonite.

[1] Memoir No. 25, Geological Survey, Dept. of Mines, pp. 56 and 89.
[2] Memoir No. 25, Geological Survey, Dept. of Mines, p. 73.

Thin sections of the rocks from which these clays were derived when examined under the microscope by Mr. Reinecke showed that one was an andesite composed of crystals of plagioclase, hornblende, and biotite, lying in a light-coloured glass, the glassy portion of the rock being in process of alteration into sericite. The other rock was a dacite ash composed of quartz and plagioclase crystals in a matrix of glass.

The amorphous glass of these rocks is easily attacked by weathering and is probably the constituent which passes so readily into the colloidal form.

Another sample of clay was collected by Dr. Ferrier from the valley of Deadman river a short distance above the mouth of Gorge creek in the Kamloops district. The clay is deposited in a flat at the base of outcrops of volcanic rock and is evidently composed of the weathered products of these rocks. It is dark grey in colour and hard when dry, but when wetted it is almost black and becomes a stiff, sticky paste, which is hard to work.

The dry clay absorbs an excessive amount of water on account of the large quantity of colloidal matter it contains and it cracks badly in drying.

Several other examples of clays, which contain an excess of colloidal material were obtained from localities where volcanic rock prevails in the bed-rock.

As clays which are residual from any other rocks do not have this property, but are on the contrary rather short in texture and lacking in plasticity, it is suggested that the volcanic rocks are the source of that gelatinous clay known as bentonite.

Volcanic Ash.

Extensive beds of white, soft material are situated along the side of the valley at Deadman lake, about 20 miles north of Savona. These deposits have attracted considerable attention for some years and samples from them have been widely distributed. The material has been variously determined as kaolin, diatomaceous earth and volcanic ash.

The locality was visited and the deposits examined and sampled by Dr. W. F. Ferrier during the summer of 1918.

A microscopic examination showed that the material contains no diatoms and as it lacks plasticity and has a low melting point—cone 9—it cannot be regarded as kaolin. The conclusion that has been reached is that the material is volcanic ash.

The following chemical analysis gives its composition:—

Silica	71·00
Alumina	14·90
Iron	1·70
Lime	1·40
Magnesia	trace.
Alkalis by difference	2·20
Loss on ignition	8·80

The sample collected by Dr. Ferrier and submitted to the physical testing laboratory for examination consisted of finely divided white powder with a number of very friable and loosely cemented lumps ranging from ½-inch to 1½-inch in diameter. A sample of this material was taken and crushed by hand in a mortar to its natural grain and a screen analysis made, with the following result:—

	Per cent.
Retained on 35 mesh	....
" " 48 "	0·10
" " 65 "	0·30
" " 100 "	0·60
" " 150 "	0·80
" " 200 "	14·50
Through 200 "	83·60

From this it can be seen that over 80 per cent of the material passes the 200 mesh. The lumps are very easily crushed to this size.

Under the microscope the material appears to consist of small, flake-like particles, transparent and of a glassy nature, many of the particles showing strain and stress lines. Occasional particles of quartz could be identified. The particles are sharp and angular.

It is possible that this substance could be used as a scouring material, as a soap filler in the manufacture of hand cleaner, or a polishing material if properly prepared.

EASTERN ONTARIO.

With the exception of a small area of shales situated to the east of the city of Ottawa the material available for the manufacture of brick and tile consists of the stoneless surface clays which are distributed in large or small patches over the region. The intervening areas between the patches of stoneless clays are covered either with stony glacial drift or boulder clay or sand and gravel. In places sand or gravel overlie the stoneless clays, and are sometimes of such a thickness as to render the clay inaccessible.

Marine Clays.

The largest areas and thickest deposits of stoneless clay are of marine origin, and are the sediments laid down in the extensive body of water or estuary which occupied the St. Lawrence and Ottawa valleys during the waning stages of glaciation.

Such clays are most in evidence in the counties bordering the Ottawa river from its junction with the St. Lawrence river as far up as the town of Pembroke, in Renfrew county. They also extend up the Bonnechere River valley as far as Caldwell, in Renfrew county.

Except for small isolated patches at Prescott, Brockville, and elsewhere, the marine clays are absent in the counties bordering the St. Lawrence river.

In the raw state the marine clay is of a monotonous grey colour, occasionally it has a reddish-brown band or layers but the prevailing colour is grey. Where roads cross it they are generally bad and in prolonged wet weather are almost impassable, owing to the pasty mass of mud into which the clay becomes worked by the passing traffic.

This clay varies in thickness from a few feet to about 200 feet in some of the river valleys. The largest areas of clay occur in Russell and Prescott counties.

The following analysis shows the chemical composition of the marine clay at Ottawa, and is representative of the area as a whole:—

	Per cent.
Silica	58·36
Alumina	20·20
Iron	4·68
Lime	4·36
Magnesia	3·50
Loss on ignition	4·73
Alkalis by difference	4·00

The marine clay is generally characterized by a sticky type of plasticity, poor drying qualities, and high shrinkages in drying. It burns to a fairly hard and very porous red coloured body at low temperatures, but is easily overfired and softened if subjected to higher temperatures. The commercial limit of burning is about 1,800 degrees Fahr. if a pyrometer is used. If pyrometric cones are used as firing checks the limit will be at about cone 06. A reference to the table of physical tests shows that the clay matures at cone 010, that it is not much improved by burning to cone 06, but that it is not safe to go beyond this or overfiring will ensue. For this reason it would be futile to attempt to use it for the manufacture of vitrified wares.

Lake Clays.

The marine clays extend westward into Leeds, Lanark, and Renfrew counties, being worked for brickmaking at Brockville, Smiths Falls, and Carleton Place. To the west of these points the stoneless clays worked for brickmaking are different in some respects to the marine clay and are probably sediments deposited in former lake basins which were partly bordered by glacial ice.

The lake clays nowhere attain to the thickness or form such extensive plain-like areas as the marine clays of the Ottawa and St. Lawrence valleys, but are confined to small isolated patches in a region where the surface materials are mostly either stony clay, or sand and gravel, or large areas of bed-rock wholly bare or covered with only a thin coating of glacial drift. The deposits of lake clay are larger and more frequent near the shore of lake Ontario than in the upland region to the north. The small patch of stoneless clay at Tweed, in Hastings county, is the only brick clay deposit along the Canadian Pacific railway between Smiths Falls and Peterborough, a distance of 134 miles, while along the line of the Grand Trunk railway, situated much nearer the shore of Lake Ontario, there are several workable deposits of brick clays, besides those now worked at Kingston, Napanee, and Belleville.

The lake clays in eastern Ontario like the marine clays are of a prevailing grey colour, but they are much oftener stratified in thin layers than the latter, which are more inclined to be massive and structureless, especially in the upper portion.

The lake clays are rather coarser in texture and not so pasty when wet, consequently the shrinkage on drying is not so great and drying troubles are not so frequent. The colour obtained on burning all the surface clays is red, but at a few points the underclay burns to a buff colour. The lake clays do not shrink so much on burning as the marine clays, and they will stand a slightly higher temperature without danger of overfiring.

CLAYWORKING INDUSTRY.

The clayworking industry of eastern Canada is at present confined to the manufacture of common brick made by the soft-mud process and to field drain tile, using the stoneless surface clays for this purpose. The large shale brick plant at Russell, in Russell county, erected for the manufacture of face brick, was not in operation during the past season.

The common brick plants use the simplest means of production and the smallest possible amount of machinery, hence they can afford to lie idle during the long winter period, as the interest charges on capital invested are small. There is a tendency to overload the clay with sand when making the mixture, and while this makes the working and drying easier and reduces the shrinkages, it also lowers the strength of the brick, the underburned ones especially being very weak and practically useless for structural purposes.

Fire checking is a common defect in the bricks made at several of the yards using both marine and lake clay. This defect consists of cracks partly or wholly across the brick which consequently break in two or more pieces when handled. A series of experiments were undertaken by the writer to remedy this defect, with the result that the easiest method was to add about 1 per cent of common salt to the wet clay when pugging. The addition of salt is very effective in assisting in the drying and afterwards preventing the fire checking. The salt addition is tried at the brickyard at Arnprior and has resulted in the elimination of the waste brick formerly accumulated there.

The amount of drain tile for agricultural purposes produced in eastern Ontario is quite inadequate to supply the demand. The plants making drain tile are two in Renfrew county, at Arnprior and Renfrew, one in Leeds county, at Gananoque, and one at Foxboro, in Hastings county. These plants make brick as well as tile, but usually provide small round down-draught kilns for burning the tile.

Shale Deposits.

Among the different shale formations which occur in eastern Ontario, only two, the Lorraine and Medina, were found suitable for the manufacture of brick and tile.

The Lorraine shale is found a few miles east of the city of Ottawa and extends about 16 miles eastward.

Outcrops are seen at Ramsey, Hawthorne, and near Vars, on the Grand Trunk railway, but most of the exposure shows only a few feet in thickness of the formation, so that it is difficult to estimate the character of the material without excavating.

It is apparently similar to the grey shale worked at Toronto and Mimico, in southwestern Ontario, but is more gritty and not nearly so plastic when ground and mixed with water. Its properties as far as the behaviour on burning and the character of the ware produced is the same as the Toronto material, but unlike the latter, cannot be used alone for the manufacture of hollow ware on account of its lack of plasticity.

A mixture of marine clay and ground Lorraine shale will make a very fine grade of hollow ware for structural purposes.

This shale does not seem to possess the vitrifying qualities which would ensure the production of paving block, which is unfortunate, as ware of this kind is required in Ottawa and Montreal and is very costly to import.

The Lorraine shale is not used at present in the clayworking industry of eastern Ontario, but the products which can be made from it include wire-cut common brick, tapestry brick, dry-press brick, fire-proofing, drain tile, floor tile, etc., with good red to brown colour or flashed effects.

The Medina shale overlies the Lorraine and is restricted to a small patch of a few square miles in extent situated between the villages of Russell and Vars, in Russell county. This is a reddish, gritty material which when ground finely and mixed with water can be worked in stiff-mud machinery for the manufacture of brick.

Very fine red face brick, both rough plastic and dry-pressed, can be made from this shale, but it would require the addition of some of the highly plastic surface clays in order to produce hollow ware.

The largest clayworking plant in eastern Ontario is located at Russell, on the New York and Ottawa railway, for the purpose of working the Medina shales which outcrop about a mile north of the village.

This plant was not in operation during the last season and the stock of brick is exhausted. It is unfortunate that the fine brick made at this plant cannot be procured as it was the only good face brick produced in the district, so that brick of this class for use in Ottawa will have to be procured in Montreal or Toronto.

The Medina shale at Russell does not appear to be suitable for the manufacture of vitrified paving brick, as it is easily overfired and deformed owing to its short vitrification range.

Black fissile shale crops out on the east bank of the Rideau river, at Ottawa. The shale is rather gritty when ground finely and it carries a small amount of carbonaceous matter which causes trouble in burning. Good wire-cut brick or hollow ware can be made, however, by adding some of the marine clay which occurs overlying it.

Experiments made at the Mines Branch laboratories indicated that a mixture of equal parts of ground shale and marine clay makes a good working body in the raw state and with careful burning produces a good quality of structural wares.

The Peerless Brick Company of Ottawa are installing the necessary machinery and building a series of round down-draught kilns with the intention of making wares from the shale and clay mixtures.

Summary Table of Physical Tests on Surface Clays in Eastern Ontario.

Locality.	Laboratory number.	Percentage water required for mixing.	Percentage drying shrinkage.	Cone 010		Cone 06		Cone 03		Burned colour.	Remarks.
				Percentage fire shrink	Percentage absorp.	Percentage fire shrink.	Percentage absorp.	Percentage fire shrink.	Percentage absorp.		
Cornwall........Stormont county..	608	35	11	1	14	1	12	5	7	Red....	Badly fire checked.
Treadwell.......Prescott " ..	332	28	9	0	13	1	12	3	7	" ...	33 p. c. sand added.
Lemieux...... " " ..	333	30	10	1	13	3	8	......	......	"	Softens and deforms at cone 03.
Navan..........Russell " ..	597	31	9	0	15	1	15	......	......	" ...	" " "
Black Rapids....Carleton " ..	330	27	9	1	12	2	9	6	0	" ...	Upper clay above lock.
Rideau Junction.. " " ..	331 (a)	......	5	0	11	0	11	0	9	" ...	Very sandy clay.
Ottawa.......... " " ..	237	32	9	0	17	2	16	9	0	" ...	Upper clay, Peerless Brick Co.
" .... " " ..	235	27	6	0	17	1	15	3	3	" ...	Bottom clay, " "
Graham Bay..... " " ..	387	30	10	0	15	2	12	......	......	"	Softens at cone 03.
Fitzroy Harbour. " " ..	598	32	8·5	0	16	0	15	......	......	"	Upper clay.
" " " " ..	598 (a)	30	8	0	17	0	17	8	0	" ...	Bottom clay.
Carp............ " " ..	589	23	7	0	15	0	14	4	1	"	Upper clay.
" .... " " ..	589 (a)	23	7	0	17	0	16	5	0	" .	Bottom clay.
Pakenham.......Lanark " ..	357	30	9	0	15	......	......	......	......	" ...	Average of bank.
Arnprior........Renfrew " ..	590 (a)	30	10	1	16	2	15	......	......	"	Upper clay, Baker's brickyard.
" .... " " ..	590	28	5	0	20	0	20	10	0	Salmon.	Bottom " " "
Castleford station " " ..	591	35	9	0	11	1	10	9	0	Red....	Lower part of bank.
Renfrew ...... " " ..	592 (a)	30	10	0	17	0	16	7	0	" ...	Upper clay, old brickyard.
" .... " " ..	592	28	8	0	22	0	21	1	14	Buff....	Lower " " "
Douglas.......... " " ..	593	35	8·5	0	18	1	18	5	0	Red....	Upper clay.
White Lake..... " " .	595	35	8	1	20	2	18	......	......	"	Softens and deforms at cone 03.
Horton.......... " " ..	646	30	8	1	15	1	13	7	0	" ..	Horton twp. con. VII, lot 27.
Cobden......... " " ..	645	30	8	1	14	2	13	7	0	" ..	Upper clay.
Pembroke........ " " ..	647	24	10	2	12	2	10	7	0	" ...	Upper clay on C.N.R. line.
Smith's Falls....Lanark " .	599	31	8	1	16	2	16	8	0	" ...	Softens at cone 03.
Scotch line..... " " ..	601	31	8	0	17	0	16	7	0	" ...	Fire checked.
Brockville.......Leeds " ..	231	27	7	0	20	1	18	5	9	"	Bottom clay.
Phillipsville... " "	602	31	7	0	22	1	22	4	0	"	Fire checked.
Kingston........Frontenac " .	241	30	7	0	20	2	17	4	9	" ...	Kingston Brick & Tile Co.
" .... " " ..	263	35	7	1	23	2	19	5	6	" ...	Cataraqui creek.
" .... " " .	396	30	9	0	15	2	12	6	0	"	Brookside farm.
Napanee.........Addington " ..	230	30	7	1	17	3	13	8	0	"	Fire checked.
Tweed..........Hastings " ..	603	22	7	0	14	0	13	3	6	" ...	Sample from brickyard.
Madoc.......... " " ..	648	36	8	0	18	0	16	8	3	"	" " "
Stirling .... " " .	604	23	6	0	21	0	20	4	0	" ...	Rawdon twp., con. II, lot 8.
Foxboro......... " " .	649	31	7	0	16	0	16	4	7	"	Sample from brickyard.

Explanation of Physical Tests.

The clays were made up for testing without the addition of sand or any other substance except in the one instance where 33 per cent of sand was added. The clay was brought to its best plastic working condition and moulded into test pieces 4 by 1½ by 1 inch in size. Fine lines were impressed on the test pieces in order to measure the subsequent drying and burning shrinkages.

The burning was done in an oil-fired muffle kiln, the duration of burning being eight hours. Standard pyrometric cones and a recording pyrometer having a platinum rhodium couple were used as measures of the heat treatment. It was found that cone 010 went down at about 1,700 on the pyrometer, cone 06 at 1,850, and cone 03 at 1,950 degrees Fahr. as registered on the pyrometer.

The character of the burned body at the different temperatures is indicated in the tables by the shrinkage and absorption, the effect of increasing heat being to make the test pieces smaller and denser in most cases, so that under the cone 03 column the figures for fire shrinkage increase greatly and those for absorption decrease. Vitrification has been accomplished in many of the samples when raised to the higher temperature so that their capacity for absorbing water has vanished.

The tests show that the drying shrinkage of nearly all the clays given in the table is too high, and that the fire shrinkage becomes too high when the softening temperature of cone 06 is passed. The total shrinkage of the test pieces is obtained by adding the drying and fire shrinkage. Sand is added in practice to correct this shrinkage the mixtures usually adopted being three parts of clay to one part sand or two parts of clay to one part sand.

The time taken in burning has an effect on the character of the body produced in clays. If the time of firing is prolonged a denser body is produced without a raise in temperature than in the shorter time. In firing most of the red burning surface clays of Ontario in commercial kilns the body is matured at temperatures between 1,700 and 1,850 degrees Fahr., but if the temperature in the kilns should reach about 1,900 degrees most of the bricks at the top of the down-draught kilns would be softened and deformed.

POTTERY MATERIALS.

Clays.—Up to the present we are not aware of the occurrence of refractory, semi-refractory or stoneware clays in southern Ontario. Clays of this kind are generally imported from the United States or from England.

Some of the brick clay deposits in eastern Ontario may be suitable for the manufacture of flower pots, but these do not appear to be of use for any better grade of pottery. Although the brick clay may be thrown on the potters' wheel it is very liable to check in drying or in the firing. On account of the sticky character and short texture of the brick clays they are not suitable for making built or modelled pottery but they might do for ornamental tiles. Schools which have a difficulty in getting a better clay might use the local clay for the latter purpose.

Silica.—The light-coloured beds of the Potsdam sandstone and the quartzites of the Grenville series in eastern Ontario can be used as a source of silica for pottery bodies.

Talc.—There are extensive deposits of talc at Madoc, in Hastings county. The two companies which operate in that locality grind and prepare the talc for various uses, the chief of which is paper filler and toilet specialties.

A small quantity of talc is sometimes used in pottery bodies for cooking ware. It is said to impart toughness and resistance to sudden changes of temperature in pottery. The talc from Madoc will stand a temperature of about 1,350 degrees C. before softening.

Apatite.—The use of apatite has been suggested as an ingredient in a porcelain body as a substitute for bone ash[1] as these materials are both calcium phosphate.

Apatite is mined at several points in eastern Ontario. It has semi-refractory properties as it is not fused under a temperature of 1,470 degrees C.

Mixtures of apatite and talc have a far lower fusing point than either material alone. Experiments carried out in the Ceramic laboratory show that a mixture of equal parts talc and apatite will fuse at as low a temperature as 1,220 degrees C.

A pottery body compounded with a portion of this mixture would vitrify at a comparatively low temperature.

NORTHERN ONTARIO.

POTTERY AND FIRECLAYS.

In the Summary Report for 1917 the chemical analysis and physical tests were recorded of certain high grade clays which occur on the Mattagami and Missinaibi rivers.

During the summer of 1918 Mr. C. M. McCarthy, of Elk Lake, examined and sampled the deposits on his property on the Mattagami river located near the lower end of the Long Portage.

The test pits and trenches dug by Mr. McCarthy on the sloping river bank revealed several different beds of clay hitherto concealed by the drift from the top of the bank. The clay beds are found to a height of 25 feet above the river. A seam of lignite a few inches thick lies above the clay and glacial drift lies above this to the top of the bank about 125 feet above the water.

Properties of the Clays.

According to description the clay beds lying below the glacial drift vary in thickness from 2 to 25 feet but no accurate measurements were made. Ten samples were sent to the Mines Branch laboratories for examination. This is the first time that the deposits were sampled in detail.

The clays are smooth and free from coarse grit with good plasticity and working qualities. Only sample No. 10 contained a quantity of coarse quartz grains which had to be separated by washing. The contrast in colour and texture of these materials to the ordinary glacial clays of the region is very striking.

The following table shows the character of the various clays when burned in a commercial stoneware kiln to cone 7.

A portion of each sample was dipped in Albany slip glaze before firing. The glaze was found to be fully matured when the samples were drawn from the kiln.

Number of Sample.	Raw Colour.	Burned Colour	Cone 7—1270°C—2318°F. Percentage of Total Shrinkage.	Percentage Absorption.
1	Pink	Buff	16	2
2	Pink	Cream	15	2
4	Buff	Pink	16	3
5	Orange	Red	13	13
6	Orange	Red	12	12
7	Black	White	9	15
8	Drab	Cream	12	8
10	White	White	12	12
11	Light grey	Cream	13	6
12	White	Cream	....	10

[1] Summary Report, Mines Branch, 1916, pp. 108-111.

Uses of the Clays.

These clays fall into two groups: those that are high in iron and those that have a low iron content. The iron has an effect on the colour, particularly in the burned state, and also on the refractoriness. The first group, however, are fireclays with the exception of number 5, which begins to soften at cone 20—1,530° C.—and is the least refractory of the group. The others do not begin to soften until the deformation point of cones 26 and 27—1,650 to 1,670° C.—are reached.

The samples 7 to 12 are highly refractory, 10 and 12 being No. 1 fireclays as they do not deform at cone 33—1,790° C. This is the first record of the occurrence of No. 1 fireclays in Canada.

Owing to their variety of character these clays are suitable for the manufacture of quite a wide range of clay products. Numbers 1, 2, and 4 are vitrified at the temperature indicated, but have a very high shrinkage, which would require to be corrected by mixtures. These are suitable for the manufacture of stoneware goods and sewer pipe or other vitrified products as well as firebrick. Clays 7 to 11 are high grade materials which would be suitable for retorts, crucibles or firebrick in the crude state and if washed for the manufacture of electric or sanitary porcelain as well as floor and wall tiles.

Age of the Clays.

As these clays occur in such a remote region and isolated from all other known deposits of a similar kind it is desirable to compare them with clays which are accessible and which are being used in the clayworking industry.

These clays lie near the northern margin of the crystalline rocks of the Pre-Cambrian upland. The rocks exposed in the river bank a short distance north of the clays are of Devonian age. A heavy cover of glacial drift lies above the clays. The bottom of the clays was not seen.

The only other clays so far known in Canada which resemble those on the Mattagami river are those which occur in the Musquodoboit valley in Nova Scotia. Samples Nos. 1 and 2 from the Mattagami are similar in all respects to certain beds of the Nova Scotia clays which are used in the manufacture of stoneware goods in the pottery at St. John, N.B.

The Nova Scotia clays are similar to the cretaceous clays worked so extensively on the Atlantic coastal plain in New Jersey for use in many branches of the clayworking industry.

The clays in the Mattagami river are certainly pre-glacial, and may be of Cretaceous age. No fossils have yet been found in them.

ROAD MATERIALS DIVISION.

K. A. CLARK, *Chief of the Division.*

Field work for the season of 1918 in the investigation of road materials was carried on in Manitoba, in Rocky Mountains Park, Alberta, and in British Columbia. It was also planned to have continued work in Ontario along the route of the Toronto-Montreal road. The entrance into the army of R. H. Picher necessitated the postponement of this plan. Work of the Road Materials Division has been confined for the most part in the past to Ontario and Quebec. Special requests from other parts of the country made it seem advisable to extend the field of work. It was consequently arranged to co-operate with the Good Roads Board of Manitoba and the Public Works Department of British Columbia in becoming familiar with the problems connected with road building in these two Provinces, and in determining and commencing a line of work which this division was in a position to carry on and which would yield useful results. In response to a request from the Department of the Interior that materials in Rocky Mountains Park be examined, it was arranged that a day or so be spent there in looking over the ground in order that systematic work could be planned for the future.

A great many samples of rock, gravel, soils, etc., were collected during the season and sent to the laboratory at Ottawa for examination. Several samples of rock were also collected and submitted to us for examination by Mr. Faribault, of the Geological Survey, in connexion with his geological work in Nova Scotia. All these samples have been examined and results of the tests appear in the accompanying tables.

Acknowledgment is due to Mr. Henri Gauthier for his assistance in carrying on the field work in Manitoba and to both Mr. Gauthier and Mr. Picher for their part in the handling of the laboratory investigations. The Geological Survey very generously co-operated by allowing the Division use of equipment, particularly in the matter of a Ford car, in connexion with the Manitoba work. The Division also wishes to express appreciation of the cordial and enthusiastic spirit shown toward it by the Highway Departments of Manitoba, British Columbia, and of Rocky Mountains Park. Mr. Lyons, chief engineer of the Manitoba Good Roads Board, Mr. Foreman, Public Works engineer for British Columbia, and Mr. Wardle, Superintendent of Rocky Mountains Park, spared no effort in putting every facility that would aid the work at the disposal of the Road Materials Division. Their assistants were always ready with time and attention to help in any way.

The main object of the season's work in Manitoba as well as in the other provinces of the west was to observe conditions and try to determine what is to be the field of activity of the Road Materials Division in aiding in the handling of the highway problems of this part of the Dominion. In order to be systematic, however, attention in Manitoba was confined to the neighbourhood of Winnipeg and to the route of the Winnipeg-Brandon road. All deposits of rock and of gravel were examined. These materials are far from general in their occurrence. Rock is confined to the limestone of several deposits in the Winnipeg neighbourhood, gravel occurs in eskers such as that at Bird's Hill, northeast of Winnipeg, in the beaches of ancient Lake Agassiz, and in the delta deposits of the Assiniboine river around Brandon. For the most part, rock and gravel are not available, except at very considerable expense, for rural road construction work.

It seems obvious that for the improvement of the majority of the rural roads, improved methods of earth road construction will have to be depended upon. Acting on this conviction, especial attention was paid to soils and many samples were collected over the entire route from Winnipeg to Brandon. These samples were calculated to represent all the types present and to be a basis for experiments in mix-

tures of soils for making sand-clay road surfaces and for use in investigations in bringing out the desirable and suppressing the bad physical properties by whatever means that can be devised. While all soil samples collected have been examined, the investigation of the soils from the road material standpoint has only been started. A necessary preliminary step, however, has been made and work will continue until, it is hoped, some practical result will be reached.

Two days only were spent at Rocky Mountains Park. The time was spent in going over the auto road through the park and noting conditions. Samples of rock, shale, and gravel that it was thought desirable to collect for laboratory examination for preliminary information in planning further work in the park were collected later by the park staff.

A month and a half was spent in British Columbia in visiting the different engineering districts and going over the roads with the district engineers. A good many samples of rock, gravel, and soil were collected. Around Vancouver samples were obtained from all the quarries which supply stone to the city.

The problem in British Columbia, and also at Rocky Mountains Park, is to secure a satisfactory road surface by the use of the materials occurring on or close to the right of way. Because of the mountainous nature of the country, it is not practicable to go far afield for material. The roads, for the most part, keep to the valleys where deposits of gravel are of pretty general occurrence. Deposits of weathered rock fragments are frequently met which give good results when placed on the road. Soil conditions vary. The large silt deposits in the interior of the Province, such as those in the Thompson, Okanagan, and Columbia valleys, are prominent features along the roads in these parts. They do not provide very satisfactory road surfaces, although it is only the silt of the Thompson valley that is particularly troublesome. The traffic on the highways is not heavy. The roads serve mostly as a means of access to the country. They are not called upon to carry much traffic of a commercial nature. Automobile touring, however, is commencing to become an important factor that must be reckoned with in the road construction programme. Just as soon as missing links in the provincial system of roads are built providing through routes through the country, a large volume of tourist auto traffic will be ready to avail itself of the splendid mountain scenery that will be made accessible. This traffic will call for road surfaces with the best binding quality that it is practicable to provide. It will be a considerable time before bituminous surfaces can be built. The immediate problem is to get the best results possible with the materials such as gravel, weathered rock and the natural soils, which are at hand. This is a problem in which it would seem that the Road Materials Division can be of use and it is to this problem that it is planned that its attention, for the present, will be turned.

TESTS ON BED-ROCK.

During the year a considerable number of samples of broken stone from quarries and rock deposits have been tested. Samples were obtained from Nova Scotia, Manitoba, Rocky Mountains Park, Alberta, and British Columbia. The results of tests on these samples are recorded in the accompanying tables.

The tests for specific gravity and water absorption need no explanation. Absorption results are reported as pounds of water absorbed per cubic foot of rock.

The abrasion test duplicates in a practical laboratory way, the abrasive action of traffic on the stone in a road-bed. The test is made on fifty pieces of stone of cubical shape, and of about the same size, which in the aggregate weigh 5,000 grams (11 pounds). This charge is revolved for 10,000 revolutions in an iron cylinder (20 by 34 cms.) set at an angle of 30° across the axis. The percentage by weight of the charge worn to powder by this operation is reported as the per cent of wear. The French co-efficient of wear is calculated from the per cent of wear by dividing the latter value into 40. Values for the French co-efficient of wear vary over a wider range than

values for the per cent of wear for the same change in the quality of rock, and also show increasing values for increasing resistance to wear.

The hardness test measures the resistance possessed by a rock to wear produced by dry grinding with an abrasive. Two cores 1-inch diameter, and cut from a solid block of the rock by a diamond drill, are used in the test. These cores are fastened in holders, and are made to rest on end under the pressure of a fixed total initial weight, on a revolving disc carrying a standard artificial quartz sand. The loss in weight of each core during 1,000 revolutions of the disc is noted. One-third of the average loss of the two cores subtracted from 20 is reported as the hardness of the rock.

The toughness test measures the resistance of a rock to fracture by impact. It is intended to duplicate the stresses undergone by rock fragments in a road-bed through the impact of horses' hoofs and of swiftly moving vehicles passing over slight obstructions in the roadway. The test is made on cylinders 1-inch diameter and 1-inch high, carefully prepared from diamond drill cores. The cylinders are subjected to blows from a 5-kilogram hammer, transmitted to the cylinders by a plunger with a spherical end resting on the cylinder. The height through which the hammer is dropped is successively increased by 1 centimetre, until the point of failure of the cylinder is reached. The height of the blow in centimetres causing failure, is taken as the toughness of the cylinder. The average of results on at least three cylinders is reported as the toughness of the rock.

A table compiled by the United States Office of Public Roads, from the results of their experience in correlating the results of laboratory tests with the behaviour of rock when used in road construction, is probably the best attempt that has been made to interpret the results of laboratory tests. This table, in slightly modified form, is given below. Reference to it will give a general idea of the type of road construction for which a rock, on which results of tests are available, is suited.

General Limiting Values for Broken Stone.

(United States Office of Public Roads, Washington, D.C.)

Type of Construction.	Traffic.	Limiting Values.			
		% Wear.[2]	Fr. Coef.	Toughness.	Hardness.
Water-bound macadam, plain or with dust palliative treatment	Light	8·0 to 5·0	5 to 8	5 to 9	10 to 17
	Moderate	5·0 to 2·5	9 to 15	10 to 18	14 or over
	Heavy	2·5 or less	16 or over	19 or over	17 or over
Macadam with bituminous carpet	Light to moderate	8·0 or less	5 or over	5 or over	(5)
Bituminous macadam with seal coat	Moderate to heavy	5·5 or less	7 or over	10 or over	
Bituminous concrete	Light to moderate	5·5 or less	7 or over	7 or over	(5)
	Moderate to heavy	4·0 or less	10 or over	13 or over	
Binder course for sheet asphalt or Topeka type	Any	5·5 or less	7 or over	6 or over	(5)
Portland cement concrete	Moderate to heavy		(4)	8 or over	16 or over
Stone paving block[3]	Any		(4)	9 or over	16 or over
Broken stone foundations... Cement concrete foundations	Any	13 or less	3 or less	3 or over	8 or over

1 Light traffic is assumed as less than 100 vehicles per day, moderate traffic between 100 and 250 vehicles, and heavy traffic over 250 vehicles per day.

2 Limiting values for the per cent of wear are not given in the table as published by the United States Office of Public Roads. The limits given in the above table are based on the limiting values for the French coefficient of wear, and are included for the convenience of those who prefer to think in terms of per cent of wear rather than in terms of French coefficient.

3 Crushing strength of 20,000 pounds, or greater per square inch, is frequently required.

4 Limits for French coefficient of wear (or per cent of wear), are not at present considered necessary for this type of construction.

5 Numerous tests have shown that limits for hardness are unnecessary if the material possesses the required French coefficient of wear (or per cent of wear) and toughness.

TESTS ON GRAVEL.

The results of all tests made on gravel samples by the Road Materials Division to date are recorded in the accompanying tables. The samples tested represent material occurring along the Hull-Montreal road in the counties of Two Mountains and Vaudreuil, along the Toronto-Montreal road from the Quebec boundary west to Prescott and from Napanee west to Port Hope, in the neighbourhood of Winnipeg and along the Winnipeg-Brandon road between these two cities, along the Banff-Kananaskis road in Rocky Mountains Park, Alberta, as well as a number of deposits in the various engineering districts of British Columbia. A number of samples of Saskatchewan gravels from the neighbourhood of Regina were tested in the Road Materials Laboratory by L. Reinecke. These results have been reported in a Geological Survey publication.[1]

The sampling and testing of gravel has not as yet been developed to a very satisfactory state. One of the problems to which this Division is giving attention is the improving of methods of sampling and testing of this material so as to secure data of more practical value. The figures recorded in the tables are intended simply to give a general indication of the gravel deposit in question by showing its character, *i.e.* the percentage of boulders (over 3-inch in diameter) which occur, the durability of the material of which the pebbles are made, and the proportion in which gravel and sand occur, and also the grading according to sizes of the particles making up the gravel and sand constituents. Gravel deposits are practically always variable in their grading from point to point. One mechanical analysis cannot, as a consequence, express the grading of the material. As already said, it can only be an indication, and its value will depend on the judgment of the collector in choosing a sample which will best represent the bulk of the material available for use. It is useless, if not deceptive to give results in anything more than round numbers. In any case, present criteria for the practical interpretation of such results demand no greater accuracy. The collecting of all samples reported upon has been carefully done and the results can be relied upon to give the best information that a single set of figures can do.

The percentage of boulders is determined by a field inspection of the gravel face exposed in the deposit. The classification of the material of which the pebbles are composed into durable, intermediate, and soft is made by the examination of a hundred or more pebbles. The pebbles are cracked with a hammer to reveal the nature of the rock. Experience in testing rock for road building properties enables one to judge with considerable accuracy the durability of the material. The durable class includes pebbles composed of rock which would give, in the abrasion test for wear, less than three per cent of wear, the intermediate class between three and six per cent wear, and the soft class greater than six per cent of wear. The proportion of gravel to sand is obtained in the operation of making the mechanical analysis. Screens with circular openings designated by the diameter of the opening and Tyler standard sieves with square openings designated by the number of meshes or openings to the inch are used in making the mechanical analysis. In the case of the Manitoba gravel samples, cement mortar tensile strength tests were made. This was done at the request of the Manitoba Good Roads Board. Compression tests would have been more satisfactory but unfortunately large enough samples were not available in many cases.

Probably the best attempt at setting limiting values for the interpretation of tests on gravel has been made by the United States Office of Public Roads. Their schedule is here quoted.

[1] Geological Survey Memoir No. 107.

Interpretation of Results of Physical Tests.

(U. S. Office of Public Roads, Washington, D.C.)

GENERAL LIMITING TEST VALUES OF GRAVEL.

(*a*) Gravel to be used in road construction to be composed of hard, durable fragments of rock, together with sand clay or other binding material, with the proportions of the various sizes as noted below.

(1) For use in the base course of gravel roads.

All to pass a 2½-inch screen and to have at least 55 and not more than 75 per cent retained on a ¼-inch screen.

At least 25 and not more than 75 per cent of the total coarse aggregate (material over ¼-inch in size) to be retained on a 1-inch screen.

At least 65 and not more than 85 per cent of the total fine aggregate (material under ¼-inch in size) to be retained on a 200-mesh sieve.

The cementing value of the material under ¼-inch to be at least 50.

(2) For use in the top course of gravel roads.

All to pass a 1½-inch screen and to have at least 55 and not more than 75 per cent retained on a ¼-inch screen.

At least 25 and not more than 75 per cent of the total coarse aggregate to be retained on a ¾-inch screen.

At least 65 per cent and not more than 85 per cent of the total fine aggregate to be retained on a 200-mesh sieve.

The cementing value of the material under ¼-inch to be at least 50.

(*b*) Gravel for use in portland cement or bituminous concrete road construction to consist of sound, hard, durable particles of stone of the following sizes:—

(3) For use as coarse aggregate in portland cement or bituminous concrete roads.

All to pass a 1½-inch[1] screen and to be retained on a ¼-inch screen, and to have at least 25 and not more than 60 per cent retained on a ¾-inch screen.

TESTS ON SOIL SAMPLES.

Tests on soil samples were arranged with the object in view of obtaining data which would relate the physical properties of the soil with its behaviour as a road surfacing material. It is hoped that by proceeding in this way the soil composition which will give the most satisfactory results will be indicated and the direction revealed in which modification should be made in the naturally occurring soils in order to improve their road building properties.

The grading of the soil is expressed in terms of clay or fine silt, silt and sand. The clay or fine silt content is determined by a process of washing, the percentage loss in weight due to the operation being expressed as clay. The soil sample is placed in a large test tube, 1½ inches by 10 inches, the test tube filled with water containing a little ammonia and shaken till the material becomes free from lumps and thoroughly dispersed through the water. The test tube is then placed in a rack and left perfectly quiet for eight minutes when the turbid suspension of clay and other fine material is siphoned off. This operation is repeated until the sample is depleted of fine material. The washed material is dried and subjected to mechanical analysis. The portion passing the 200-

[1] When used in bituminous concrete construction all to pass a 1¼-inch screen.

mesh sieve is named silt, anything retained on this mesh is called sand. The percentage of the sand which is retained on the 65-mesh is noted by way of indication of the grading of this constituent.

In order to relate the mechanical analyses of the soils to their behaviour as road surfacing materials, two tests were made on the samples which were calculated to evaluate the stability, in a comparative way, of the soils under dry and under wet conditions. Briquettes of the natural soil two and one-half centimetres in diameter and two and one-half centimetres in height were moulded in a hydraulic press under a pressure of 132 kilograms per square centimetre. These were allowed to dry in the air during a period of several weeks after which time their compressive strength was determined. Another sample of soil of about one thousand grams in weight was damped and uniformly packed into a tin pannikin four inches wide by two and one-half inches deep. The pannikin was perforated to allow drainage. The soil was brought to a rounded surface, just above the edge of the dish. A series of samples prepared in this way were allowed to dry in the air when observations on the surfaces produced were made. They were then placed outdoors and the spray from a garden hose allowed to fall on them in a way to duplicate as nearly as possible a natural rain. The spraying was continued generally during a whole night. The intention was to give the samples a chance to get as wet as a rain would make them when exposed under conditions similar to those which exist in the case of a road. The surfaces were again noted and observations made. The stability was then tested by means of an apparatus devised to give comparative values on bearing strengths of the wet soils. The essential feature of the apparatus was a right angled, V-shaped piece of brass, two-tenths of an inch thick. The weight in pounds necessary to cause this angle to penetrate one inch into the wet soil was recorded.

The investigation of the soils so far has simply been preliminary. A method for their examination has been adopted and descriptive information of the soils with which it is necessary to deal has been obtained. It still remains to seek ways and means, whether by the mixing of different available materials or by other schemes, of producing from the soils a more stable and serviceable road surface than they naturally give. This investigation will proceed.

The sand-clay type of construction, which has been extensively used in many parts of the United States, naturally suggests itself when considering the road problems in Manitoba. In this connexion the following points, deduced from experience in sand-clay road construction in North Carolina, are interesting.

[1]The field and laboratory experiments which have been made would seem to justify the following conclusions:—

1. That 60 to 80 per cent of sand is necessary to obtain a hard surface, and that the best soils will contain 45 to 50 per cent of sand retained on a 60 mesh sieve.

2. That sand passing a 100-mesh sieve and retained on a 200-mesh sieve has little hardening value to the road surface, but does aid in filling the voids; and that roads constructed only of sand of this fineness will not be satisfactory.

3. That when less than 40 per cent of sand is retained on a 60-mesh sieve, the resulting road surface is very noticeably softer than where coarser sand is used.

4. That if there can be 10 to 15 per cent of gravel varying from that which passes a 1-inch screen and is retained on a 10-mesh sieve, it has a very decided effect in increasing the hardness and efficiency of the road.

5. For the best results, the clay content will vary from 10 to 20 per cent.

6. An excess of 30 per cent of clay in the soil will give a soft surface that will get very muddy in wet weather.

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[1] American Highway Engineers' Handbook, by A. H. Blanchard. From Chapter on Earth and Sand-Clay Roads by J. H. Pratt, consulting engineeer and secretary, North Carolina State Highway Commission.

TESTS ON WEATHERED ROCK.

Deposits of fragments of weathered rock, as mentioned before, are of frequent occurrence in the mountain country. Such material finds its way onto the road surface with results which are often quite satisfactory under the conditions of traffic which exist. The weathered rock quickly breaks down into fine material and the final result is a type of earth road. Any virtue this road may have over a natural dirt road would seem to be because of the better physical properties of the dirt formed from the broken down rock. The presence of a considerable percentage of unbroken rock fragments in the general mass forming the surface will also aid in producing a stable condition. (Compare point five in quotation on sand-clay road construction). The tests to which samples of weathered rock were subjected were arranged on the assumption that the controlling factor for suitability of such a material is the properties of the "earth" that will be formed when it is broken down by traffic. Samples were consequently ground in a ball mill and the stability of the resultant product under dry and wet conditions determined in the same manner as in the case of soils.

Results of Tests on Bed-rock.

NOVA SCOTIA.

Locality	Rock Type	Physical Properties.					
		Per cent of wear.	French coef. of wear	Toughness	Hardness	Specific gravity	Absorption in lb. per cu. ft.
Ohio Road Quarry, 2 miles north of Town of Shelburne, N.S.	Diabase................	2·4	16·7	14	18·5	2·88	0·2
Reid's quarry, Jordan Falls, Shelburne Co., N.S.	Diabase	2·5	16·0	16	17·8	2·89	0·5
Black Point, below Liverpool, N.S. ...	Diabase..	2·2	18·2	10	16·8	3·12	0·3
Cherry Cove, Lunenburg Co., N.S...	Diabase.....	2·5	16·0	15	17·9	2·87	0·9
Sable River, Shelburne Co., N.S....	Schistose, micaceous quartzite.	2·1	19·0	14	16·7	2·71	0·4
From stock pile on streets of Halifax, N.S.	Quartzite or "Whin" rock.	2·3	17·4	....	..	2·68	0·9
Sable River, Shelburne Co., N.S....	Mica Schist........... ..	6·8	5·9	....	....	2·78	0·9

MANITOBA.

Manitoba Quarries Co., Stoney Mountain, Man.	Limestone..........	3·9	10·2	5	13·2	2·54	2·9
Wallace Sandstone Co., Garson, Man..	Limestone......	10·7	3·9	3	3·7	2·31	5·0

ALBERTA.

Mt. Rundle, Banff, Alta........	Limestone	3·3	12·3	6	14·9	2·72	0·5

BRITISH COLUMBIA.

Locality.	Rock Type	Physical Properties.					
		Per Cent of Wear	French coef. of wear	Toughness	Hardness	Specific gravity	Absorption in lb. per cu. ft.
Nelson-Brilliant Road, near Nelson, B.C.	Granite (Glacial Boulders).	2·6	15·4	10	18·3	2·67	0·7
From stock pile of crushed rock from Rossland Mine, dumped on Rossland-Trail road.	Mixture of igneous types.	2·9	13·8	.....	....	..	.....
Kelowna, B.C.	Trachyte	2·9	13·8	16	18·3	2·27	4·7
Rock talus, Indian Reserve, near Kamloops, B.C.	Trap	3·7	10·9	.	.....	2·74	0·1
Marble Canyon, Lillooet District, B.C.	Limestone	4·2	9·6	4	15·2	2·69	0·4
Rock slide, Lillooet-Lytton Road, B.C.	Sandy Tuff	2·6	15·4	10	19·0	2·71	0·5
Mt. Begby, Cariboo Road, B.C.	Granite	3·1	13·1	7	16·2	2·92	1·0
Vedder Mountain Quarry, Sumas Municipality, B.C.	Gabbroic Rock	2·8	14·3	14	18·0	2·80	0·4
Nicomen Quarry, Nicomen, B.C.	Pink granite	5·2	7·7	14	18·3	2·61	0·5
	Aplite	2·3	17·4	17	18·8	2·76	0·3
Gilley Bros. Quarry, Pitt Lake, B.C.	Granite	2·1	19·0	12	18·7	2·56	0·3
Granite Quarries, North Arm of Burrard Inlet, B.C.	Granite	2·8	14·6	8	18·8	2·69	0·3
Coast Quarries, North Arm of Burrard Inlet, B.C.	Granite	2·6	15·4	10	18·9	2·69	0·4
Scott Goldie Quarry, North Arm of Burrard Inlet, B.C.	Aplite	2·0	20·0	23	18·9	2·66	0·6
District of N. Vancouver quarry, N. Vancouver, B.C.	Granite	2·9	13·8	9	18·7	2·64	0·5
Whinstone Quarry, Horseshoe Bay, Howe Sound, B.C.	Aplite	1·7	24·2	12	18·6	2·84	0·2
Deeks Gravel and Rock Co., Porteau, Howe Sound, B.C.	Trap (from quarry)	2·1	19·0	23	18·6	2·76	0·1
	Trap (from gravel bank).	2·0	20·0	20	18·7	2·78	0·5
	Granite (from gravel bank).	2·2	18·2	10	18·9	2·67	0·6
Rosebury St. rock cut, Victoria, B.C.	Granite	2·4	16·7	16	18·8	2·75	0·6
Northwest Supplies quarry, Parson's Bridge, Esquimalt Harbor, B.C.	Limestone	4·1	9·8	10	14·5	2·70	0·1
Producer Rock and Gravel Co., Albert Head, Vancouver Island, B.C.	Trap	2·0	20·0	17	17·5	2·89	0·6

Results of Tests on Gravel Samples.

*TWO MOUNTAINS AND ARGENTEUIL COUNTIES, QUE.
(Hull-Montreal Highway).

Owner and Location of Deposit.	Character of Gravel.						Mechanical Analysis.													
	Per cent of Boulders over 3"	*Composition of Pebbles. Per cent of.			Proportion of Gravel to Sand, p.c. of.		Gravel. Per cent retained on screens.							Sand. Per cent retained on sieves.						
		Durable.	Interme-diate.	Soft.	Gravel.	Sand.	2½"	2"	1½"	1"	¾"	½"	¼"	8	14	28	48	100	200	Passing 200
John Tompson, Wm. Heatle, R.R. 1, St. Philippe, Co. Argenteuil, lots 25, 26, range V, twp. Chatham.	0	35	45	20	30	70	....	....	....	5	10	20	65	40	30	15	10	3	1	1
David Rodgers, R.R. 1, Lachute, Parish of St. Jerusalem, Argenteuil twp., lots 39, 40, East Settlement	20	15	30	55	70	30	....	....	....	35	30	20	15	15	5	5	20	30	15	10
J. R. Cleland, R.R. 1, St. Hermas, Municipality of St. Hermas, lot 34, East Settlement, parish of St. Jerusalem, Argenteuil Twp.	10	25	25	50	35	65	....	....	....	10	10	25	55	45	30	5	10	8	2	0
Simeon Legault, R.R. 1, Lachute, lot 1 of 31, middle settlement, Parish of St. Jerusalem, Argenteuil co.	10	10	10	80	65	35	....	....	....	20	20	25	35	40	20	15	5	5	5	10
C.N.R. pit, west of village of St. Andrews, lots 48A, 69, 71 to 79, 101 to 105, 108, 142, 159, 164, North River Range West, Argenteuil twp.	5 30 50	15	50	35	65 55 65	35 (45 (35 (	NW E part "	end of	pit) of pit) ")	55	25	10	10	15	5	20	45	15	0	0
Lots 406, 407 on Grand St. Joseph Road, Parish of St. Joseph du Lac.	5	20	5	75	70	30	....	....	....	30	15	25	30	40	10	10	10	10	10	10

Results of Tests on Gravel Samples.

QUEBEC BOUNDARY TO PRESCOTT, ONT.
(Montreal-Toronto Highway).

Owner and Location of Deposit.	Character of Gravel.						Mechanical Analysis.													
		Composition of Pebbles. Per cent of.			Proportion of Gravel to Sand, p.c. of.		Gravel. Per cent retained on screens.							Sand. Per cent retained on sieves.						
	Per cent of Boulders over 3″.	Durable.	Inter-mediate.	Soft.	Gravel.	Sand.	2½″	2″	1½″	1″	¾″	½″	¼″	8	14	28	48	100	200	Passing 200.
O. M. McCuaig, lot 36, con. I, Lancaster twp., Ont.	0	0	65	35	65	35	0	10	15	20	15	15	25	40	25	10	5	5	5	10
John Shanks, Lancaster, Ont., lot 36, con. I, Lancaster twp.	35	0	70	30	70	30	5	15	20	20	10	15	15	25	30	25	7	3	3	7
Charlottenburgh township council, lots 4, 5, con. III. Charlottenburgh twp.	25	0	35	65	80	20	0	5	15	20	15	15	30	55	15	5	5	5	5	10
A. J. Fraser, R.R.1, Summertown Stn., lots 1, 2, con. 1, Charlottenburgh twp.	40	5	10	85	65	35	10	10	15	20	10	15	20	35	25	10	10	5	5	10
T. Doherty, Summertown, Ont., lots 23, 24, con. II, Charlottenburgh twp.	5	5	50	45	75	25	5	10	20	25	10	20	10	25	15	10	20	10	10	10
D. Richardson and L. Leroux, R.R. 1, Cornwall, Ont., con. II, west end of Charlottenburgh.	15	5	25	70	55	45	0	5	15	20	10	20	30	30	25	20	10	5	5	5
Town of Cornwall, pit, C. L. Mongers, manager, Cornwall, Ont., lots 7, 8, con. II, Cornwall twp.	70	5	55	40	60	40	5	10	15	20	10	15	25	25	25	20	15	5	5	5
Father McRae, St. Andrews West, lot 11, con. V, Cornwall twp.	35	5	70	25	65	35	10	15	20	20	10	10	15	15	15	20	30	10	5	5
John McIntosh, St. Andrews West, lot 12, con. V, Cornwall twp.	5	5	60	35	45	55	5	5	5	15	10	15	45	45	30	10	5	5	2	3
Thomas Cleary, Mille Roches, Ont., lot 29, con. IV, Cornwall twp.	25	0	55	45	55	45	0	10	20	20	15	15	20	25	15	20	20	10	5	5

H. Winters, R.R. 1, Mille Roches, lot 22, con. V, Cornwall, Ont.	5	5	70	25	65	35	15	20	15	25	10	10	15	15	10	15	40	15	2	3
U. J. McQuillon, R.R. 1, Harrison, lots 30, 31, con. VI, Cornwall twp.	25	0	75	25	60	40	5	20	20	20	10	10	15	20	15	20	30	10	2	3
Geo. Losey, R.R. 1, Harrison, lots 33 to 36, con. V, VI, Cornwall twp.	15	0	80	20	75	25	0	15	15	20	15	20	15	45	20	15	5	2	3	10
Wm. J. Murphy, R.R. 1, Harrison, lots 33 to 36, con. V, VI, Cornwall twp.	20	0	80	20	65	35	5	10	15	20	15	15	20	25	15	10	25	20	2	3
J. G. Adams, R.R. 1, Wales, lot 2, con. II, Osnabruck tp.	40	5	85	10	70	20	5	20	20	25	10	10	10	25	20	15	25	10	3	2
James Miller, R.R. 1, Wales, lot 14, con. I, Osnabruck tp.	25	0	60	40	65	35	10	15	20	20	10	10	15	20	20	15	30	10	2	3
Frank Smith, Lunenburg, lot 13, con. III, Osnabruck twp.	40	5	65	30	60	40	5	10	20	20	10	15	20	20	15	20	30	10	2	3
Osnabruck twp., Council pit, Part owned by W. N. Hollistor, R.R. 1, Farrans Point, lots 24 to 27, con. III, Osnabruck twp.	40	0	60	40	60	40	10	10	20	20	10	15	15	20	15	20	30	10	2	3
Malcolm A. Froats, R.R. 1, Morrisburg, lots 26, 27, con. III, Williamsburg twp.	20	0	65	35	50	50	5	10	5	30	15	15	20	25	20	15	25	10	2	3
A. Shannett, R. R. 1, Williamsburg, lot 35, con. III, Williamsburg twp.	25	5	45	50	75	25	5	10	15	25	10	15	20	35	30	20	5	3	2	5
Asa Cougler, R. R. 1, Williamsburg, lot 35, con. III, Williamsburg twp.	20	5	45	50	70	30	5	10	20	20	10	15	20	35	25	20	10	5	1	4
H. W. Doran, Morrisburg, lot 1, con. I, Matilda twp.	70	5	40	55	65	35	5	20	20	20	10	10	15	20	15	15	25	10	5	10
Albert Beckstead, Morrisburg, lot 3, con. I, Matilda twp.	25	5	50	45	65	35	5	10	20	20	10	15	20	35	25	20	10	5	1	4
William Mullin, R. R. 1, Iroquois, lot 5, con. III, Matilda twp.	60	0	65	35	65	35	5	10	15	15	10	20	25	35	20	15	15	5	5	5
Edgar Shaver, R.R. 2, Iroquois, lot 19, con. II, Matilda twp.	5	0	55	45	65	35	10	10	15	15	15	15	20	35	20	15	20	5	2	3
J. Maikley, R. R. 2, Iroquois, lots 32, 33, con. I, Matilda twp.	25	0	65	35	85	15	10	10	15	25	15	15	10	40	15	5	5	5	10	20
Rufus Froom, R. R. 2, Cardinal, lots 4, 5, Edwardsburg twp.	5	5	55	40	70	30	10	15	20	20	10	10	15	25	15	20	25	10	2	3

Results of Tests on Gravel Samples.

**NAPANEE TO PORT HOPE, ONT.

Montreal-Toronto Highway.

Owner and Location of Deposit.	Character of Gravel.						Mechanical Analysis.													
	Per cent of Boulders over 3".	Composition of Pebbles. Per cent of.			Proportion of Gravel to Sand, p.c. of.		Gravel. Per cent retained on screens.							Sand. Per cent retained on sieves.						
		Durable.	Inter-mediate.	Soft.	Gravel.	Sand.	2½"	2"	1½"	1"	¾"	½"	¼"	8	14	28	48	100	200	
Hiram Shannon, R. R. 5, Napanee, lot 6, con. III, Richmond twp.	5	5	85	10	50	50	...	...	...	25	20	20	35	35	25	20	10	5	3	2
P. Cassidy, R. R. 1, Deseronto, lot 39, con. II, Tyendinaga twp.	5	5	85	10	40	60	...	...	...	20	15	20	45	35	15	15	15	10	5	5
G. Campbell, Marysville, Ont., lot 33, con. II, Tyendinaga twp.	5	5	85	10	45	55	...	...	...	45	20	15	20	25	20	20	20	10	3	2
Indian Reserve, on York Road, 5 miles west of Deseronto.	5	5	90	5	55	45	...	...	...	25	20	20	35	35	25	20	10	5	3	2
Alex. McLelland, Belleville, lot 16, con. I, Thurlow.	20	0	95	5	55	45	...	...	...	35	15	20	30	45	20	15	10	5	2	3
John Creeper, RR.5 Belleville, lot 5, con. II, Thurlow.	10	0	95	5	40	60	...	...	...	10	25	25	40	25	10	10	10	15	15	15
C. O. Hess, R. R. 5, Trenton, lots 11, 12, con. III, Sidney twp.	10	0	90	10	50	50	...		...	25	20	15	40	40	30	15	5	5	2	3
Jas. Sandercock, R. R. 2, Trenton, lot 8, con. I, Sidney twp.	0	0	85	15	50	50	...	...	...	10	25	30	35	35	20	25	10	5	2	3
J. F. Simmons, R. R. 5, Trenton, lot 8, con. II, Sidney twp.	5	5	80	15	45	55	...	...	...	20	25	25	30	30	20	20	10	10	5	5
Norman Tompkins, Brighton, lot 31, con. A, Brighton twp.	15	15	75	10	60	40	...	...	...	50	15	15	20	25	10	10	20	20	10	5
On road allowance, lot 32, con. A, Brighton twp.	10	15	85	0	45	55	...	...	...	35	15	20	30	20	5	10	45	20	0	0

Town of Brighton, lot 35, con. I, Brighton twp.	5	0	90	10	60	40	.....	.....	.....	25	15	20	40	45	20	15	10	5	5	0
A. Swain, R. R. 4, Brighton:	5	15	80	5	50	50	.....	....	...	15	10	20	55	40	30	15	10	2	2	1
John Kellog, Vernonville, lot 11, con. II, Haldimand twp.	0	15	75	10	30	70	....	.....	...	35	20	15	30	20	25	30	15	5	3	2
Geo. Have, Andrew Speers, Thos. Hoskin, R. R. 1, Grafton, lot 51, con. I,II, Haldimand twp.	5	20	75	5	55	45	....	...	....	15	15	20	50	35	70	20	15	5	3	2
Township of Haldimand, lot 9, con. II, Haldimand twp.	30	10	80	10	55	45	.....	....	...	30	15	20	35	35	25	20	10	5	3	2
John Cochrane, Jas. McKeag, R. R. 6, Cobourg, lot 14, con. II,III, Haldimand twp.	0	15	80	5	50	50	...	...	....	10	20	25	45	55	15	10	10	5	3	2
Herbert Parsons, Camborne, lot 20, con. IV, Haldimand twp.	20	10	75	15	60	40	....	....	....	40	20	15	25	35	15	15	15	10	5	5
Arthur Watt, Port Hope, lot 33, con. IV, Haldimand twp.	5	15	75	10	40	60	..	...	......	35	10	20	35	25	20	20	15	10	5	5
John Banisey, Quay's P.O., lot 2, con. V, Hope twp.	5	...	..	..	50	50	..	.	...	65	15	10	10	20	20	25	20	10	2	3

** In the case of deposits in Two Mountains and Argenteuil Counties and along the Montreal-Toronto Highway from Napanee to Port Hope, no values are given for percentage of pebbles over 1″ in size. The 1″ screen was the largest size that the laboratory had at the time the analyses were made. The percentage recorded as 1″ in size, is thus an accumulative value for all sizes present larger than 1″.

* The composition of pebbles from a deposit is determined by inspection of about one hundred representative pebbles. They are classed as durable, intermediate or soft according as they are composed of rock which would show a per cent of wear of less than 3, between 3 and 6, or over 6, respectively. These three classes mean, practically, pebbles composed of fresh rock of igneous origin, fresh limestone, and weathered pebbles of both types.

Results of Tests on Gravel Samples.

WINNIPEG TO BRANDON, MANITOBA.

Owner and Location of Deposit.	Character of Gravel. Composition of Pebbles. Per cent of. Durable.	Intermediate.	Proportion of Gravel to Sand. Per cent of. Gravel.	Sand.	Mechanical Analysis. Gravel. Per cent retained on screens. 2½"	2"	1½"	1"	¾"	½"	¼"	Sand. Per cent retained on sieves. 8	14	20	28	48	(Passing 48) 100.	200	Passing 200	*Tensile Strength of 1:3 mortar lbs. per sq. in. 7 days.	28 days.
Sylvester Sinnot, Beausejour, Man., Sect. 33, T. 12, R. 8 E.	...	...	5	95	...	...	...	...	...	...	100	1	1	...	3	25	35	15	20	51	110
C. P. R. pit at St. Ouens, Man., Sect. 33, T. 12, R. 8 E.	...	...	...	100	...	...	...	...	...	...	...	2	5	...	10	40	35	5	3	135	211
Manitoba Pressed Brick Co., Ltd., Winnipeg, Man., pit at Beausejour, Man., Sect. 36 T. 12, R. 7 E.	...	...	5	95	...	...	...	...	...	...	100	5	10	...	5	35	20	15	10	165	238
			10	90	...	...	...	...	...	20	80	5	10	...	10	25	10	15	25	135	205
C. P. R. pit at Oakbank, Man., Sect. 19, T. 11, R. 5 E.	30	70	30	70	...	...	5	15	15	20	45	20	25	...	10	40	3	1	1	175	276
	20	80	65	35	...	5	15	20	15	15	30	30	30	...	20	15	2	1	2	288	337
Bird's Hill Sand Co., Winnipeg, pit at Springfield, Sect. 35, T. 11, R. 4 E.	20	80	30	70	...	...	10	10	20	25	35	10	20	...	20	30	15	4	1	170	168
				106	...	...	...	...	...	...	...	0	2	...	7	35	70	5	1	84	139
Braid & McGurdy Co., Ltd., Winnipeg, pit at Springfield, Sect. 36, T. 11, R. 4 E.	30	70	5	95	...	...	...	...	...	20	80	20	38	...	30	10	2	0	0	268	306
	30	70	65	35	...	...	30	25	10	15	20	20	30	...	30	15	3	1	1	238	273
C. N. R. pit, Bird's Hill, Sect. 27, T. 11, R. 4 E.	25	75	50	50	...	...	5	20	10	2	45	30	15	...	10	30	10	3	2	208	252
C. P. R. pit, Bird's Hill Stn. ...				100	...	...	...	...	...	...	...	3	15	...	10	20	45	5	2	195	291
				100	...	...	...	...	...	...	...	15	20	...	20	25	17	2	1	289	432
	20	80	15	85	...	...	...	...	25	20	55	25	40	...	20	10	3	1	1	225	270
	25	75	55	45	...	10	5	20	10	20	35	40	25	...	20	10	3	1	1	251	412
City of Winnipeg pit, Bird's Hill.			5	95	...	...	...	...	...	...	100	5	30	...	25	40	0	0	0	140	197
	25	75	60	40	...	...	5	20	20	25	30	15	15	...	20	38	10	1	1	220	362
Cusson Lumber Co., Ltd., St. Boniface, Man., pit at Ste-Anne-des-Chênes, lot 8.	...	...	...	100	...	...	...	...	...	...	...	0	2	...	10	60	25	2	1	139	243
Thos. Kelly & Sons, Winnipeg, pit at Stoney Mountain, Sect. 11, T. 13, R. 2 E.	15	85	65	35	...	10	15	30	10	15	20	15	15	.	15	40	10	2	3	185	266

Winnipeg Electric Railway pit, Stoney Mountain.	....	100	65	35	5	5	5	30	20	15	20	35	20	....	20	15	3	3	4	222	339
C. N. R. pit, Burns Ridge, Drake, Man., Section 31, T. 13, R. 1 E.	25	75	70	30	....	10	15	20	10	15	30	30	20	....	15	15	13	2	5	170	150
E. Williams & Co., Stonewall, pit at Gunton, Man., Sect. 21, T. 15, R. 2 E.	20	80	45	55	....	....	...	10	10	25	55	25	10	....	10	20	25	8	2	112	200
The Stonewall Gravel Co., Ltd., pit at Balmoral, Man., Sect. 6, T. 15, R. 2 E.	20	80	55	45	....	15	10	15	10	20	30	25	15	...	15	25	6	4	10	190	248
C. P. R. pit, Teulon, Man., Sect. 19, 30, T. 16, R. 2 E.	15	85	60	40	...	15	10	25	15	15	20	15	20	....	20	35	4	1	5	......	
Municipality of Rockwoods Gunton, Man., Sect. 9, T. 16, R. 2 E.	5	95	25	75	....	....	....	..	....	25	75	25	20	....	15	30	7	2	1	130	169
Municipality of Rosser, Man, Sect. 18, T. 12. R. 1 E.	....	100	65	35	....	...	...	10	20	25	45	35	25	...	20	10	4	1	5	195	360

The occurrence of boulders in the Manitoba gravel deposits examined is insignificant.

Mechanical analyses of samples from Manitoba deposits were obtained in some cases in the field with a set of four sieves (3, 8, 20 and 48 mesh), while in other cases more complete analyses were made on samples sent into the laboratory. Samples for which values for the tensile strength of cement mortars appear in the table were analysed at the laboratory with a complete range of screens and sieves. Results of both field and laboratory analyses are recorded. Figures occurring in the sixth column for mechanical analyses of sand are values for material passing the 48-mesh sieve or for material retained on the 100-mesh sieve according to whether the analysis is one that was made in the field or in the laboratory. The 20-mesh sieve was not used in the laboratory analyses.

Several analyses are given in the case of some of the larger deposits or excavations to indicate a range of variation that was apparent from inspection of the gravel face. (This does not mean that when only one analysis is given, no variation in the deposit occurs.)

*Ottawa Standard Sand Tensile strength of 1:3 mortar: 7 days—197 lbs. per sq. in. 28 days—302 lbs. per sq. in.

Results of Tests on Gravel Samples.

Owner and Location of Deposit.	Character of Gravel. Composition of Pebbles. Per cent of. Durable	Inter-mediate	Proportion of Gravel to Sand. Per cent of. Gravel.	Sand.	Mechanical Analysis. Gravel. Per cent retained on screens. $1\frac{1}{2}''$	$1''$	$\frac{3}{4}''$	$\frac{1}{2}''$	$\frac{1}{4}''$	Sand. Per cent retained on sieves. 8	14	20	28	48	(pass'g 48) 100	200	pass'g 200	Tensile Strength of 1:3 mortar. 7 days	28 days.
McDougall, L. Perras, St. François, Man., lots 183, 184, Mun. of St. François-Xavier.	20	80	45	55	(West end of deposit)					35		45		18	2				
			0	100						0		65		50	5				
			10	90				10	90	40		30		20	10				
			10	90						20	15		15	25	20	5	2	323	445
			0	100	(East end of deposit)					3		7		40	50				
Sam Smith, St. François, Man., lot 150, Mun. of St. François-Xavier.			0	100						0		0		60	40				
			0	100						0		0		65	35				
			0	100						0		0		5	95				
J. H. McClarey, Meadows, Man., Sec. 21, T. 12, R. 2, Mun. of Rosser.	45	55	20	80						40		40		15	5				
			30	70						40		40		15	5				
			5	95						30		55		15	0				
			30	70			25	15	60	20	20		25	20	5	5	5	298	445
On road allowance between Sec. 18, R. 4, and Sec. 13, R. 5, T. 13, between Portage and Woodlands municipalities.	0	100	15	85						50		45		5	0				
			10	60						55		40		5	0				
			30	70						60		35		5	0				
			35	65			5	15	80	40	30		20	5	1	2	2	323	400
Chas. Bannerman, Portage, Man., Sec. 14, T. 13, R. 5, Mun. of Portage la Prairie.			0	100						10		50		35	5				
			0	100						10		15		60	15				
			0	100						5	15		20	40	20	0	0	150	225
Jas. Stewart, Portage, Man., Sec. 9, T. 13, R. 5, Mun. of Portage.			25	75						30		35		30	5				
			10	90					100	25	26		20	25	5	1	4	200	255
Jas. Murray, Portage, Sec. 5, T. 13, R. 5, Mun. of Portage.	10	90	25	75						20		25		45	10				
			5	95					100	15	15		15	30	20	3	2	170	246
Ed. VanBuskirk, High Bluff, Man., Sec. 13, T. 13, R. 6, Mun. of Portage.			10	90					100	15	20		20	30	15	0	0	218	295
A. Code, High Bluff, Man., Sec. 13, T. 13, R. 6, Mun. of Portage.			5	95					100	5	30		25	20	20	0	0	231	244
R. J. Walker, Flee Island, Man., Sec. 13, T. 13, R. 6, Mun. of Portage.	15	85	30	70			25	20	55	15		15	20	40	5	2	3	236	378
Sec. 24, T. 13, R. 6, Mun. of Portage	10	90	55	45	5	15	20	25	35	30		15	15	25	10	1	4	268	290
Burnside Beach, Kinosota Ridge.																			
Kenneth McKenzie, Portage, Man., Sec. 14, T. 12, R. 8, Mun. of Portage	50	50	10	90					100	10		10	10	15	55	0	0	135	203

Wm. Oliver, Portage, Man., Sec 15, T. 12, R. 8, Mun. of Portage.	...	...	15	85	...	...	...	...	...	15	...	30	...	45	10				
Thos. Paul, Bagot, Man., Sec. 26, T. 12, R. 9, Mun. of Westbourne.	...	...	0	100	...	...	...	...	...	2	...	3	...	25	75				
C. P. R. pit, Sec. 5, T. 14, R. 9, Mun. of Westbourne.	...	...	15	85	...	...	...	...	...	15	...	25	...	25	35				
(Campbell Beach), Arden Ridge.																			
F. A. Thompson, Austin, Man., Sec. 19, T. 11, R 11, Mun. of N. Norfolk.	40	60	20	80	...	15	10	20	55	20	20	...	25	15	20	0	0	227	319
	...	...	20	80	...	15	15	20	50	15	20	...	25	25	15	0	0	214	250
C. P. R. pit, Sec. 24, T. 11, R. 12, Mun. of N. Norfolk.	45	55	25	75		(nor	th p	it)		35	..	25	...	20	20				
	...	...	30	70	...	...	25	20	55	35	15	...	10	5	35	0	0	233	373
	...	...	15	85		(sou	th p	it)		30	...	25	...	20	25				
On right-of-way, Sec. 26, T. 11, R. 12, Mun. of N. Norfolk.	...	...	5	95	...	...	...	...	...	25	...	25	...	20	30				
G. T. P. pit, Sec. 3, T. 12, R. 13, Mun. of N. Norfolk.	...	...	5	95	...	...	...	...	...	20	...	30	...	25	25				
Beside right-of-way, Edrans, Man., Sec. 36, T. 12, R. 13, Mun. of Langford.	...	...	5	95	...	...	...	...	...	15	...	20	...	35	30				
Neighbourhood of Brandon.																			
Municipality pit, Sec. 35, T. 11, R. 17, Mun. of Elton.	...	...	10	90	...	...	...	...	...	15	...	25	...	50	10				
Alex. Fischer, Madford, Man., Sec. 15, T. 11, R. 17, Mun. of Elton.	40	60	30	70	...	...	...	...	...	35	...	45	...	15	5				
	...	...	30	70	...	...	5	25	70	30	20	...	20	25	5	0	0	166	307
Municipality pit, on right-of-way between N. Cypress and Elton, between Secs. 1 and 6, T. 11, R. 16 and 17.	...	...	5	95	...	...	...	...	...	15	...	50	...	25	10				
	...	...	10	90	...	...	...	65	35	15	40	...	15	10	20	0	0	267	382
Municipality pit, Douglas, Man., Sec. 3, T. 11, R. 17, Mun. of Elton.	25	75	20	80	...	...	...	...	...	20	...	50	..	25	5				
	...	...	25	75	...	25	25	20	30	10	15	...	25	35	15	0	0	160	199
D. W. Agnew, Douglas, Man., Sec. 33, T. 10, R. 17, Mun. of Cornwallis.	25	75	40	60	(E.	part	of	pit)		25	...	25	...	40	10				
	...	...	30	70	(S.	W.	part	of	pit)	45	...	35	...	10	10				
	...	...	20	80	(S.	part	of	pit)		40	...	25	...	20	15				
	...	...	30	70	...	...	...	...	...	35	25	...	10	5	25	0	0	223	330
Fred Grant, Chater, Man., Sec. 35, T. 10, R. 18, Mun. of Cornwallis.	90	10	60	40	...	...	...	...	...	65	...	10	...	10	15				
	...	...	30	70	...	...	...	...	...	45	...	25	...	25	10				
	...	...	40	60	...	...	35	25	45	45	20	...	10	10	10	2	3	212	336
City of Brandon pit, Sec. 26, T. 10, R. 19, Mun. of Cornwallis.	35	65	10	90	...	...	...	...	...	10	...	15	...	40	5				
	...	...	40	60	...	...	...	...	...	55	...	20	...	20	5				
	...	...	35	65	...	...	30	25	45	30	20	...	15	10	20	5	0	215	281
On road allowance, between Secs. 29 and 30, T. 10, R. 19, Mun. of Cornwallis.	35	65	30	70	...	...	20	20	60	40	35	...	15	5	5	0	0	225	350
On road allowance, between Secs. 30 and 25, T. 10, R. 19 and 20 Mun. of Cornwallis.	35	65	30	70	...	10	15	25	50	30	25	...	15	5	20	5	0	219	338

Results of Tests on Gravel Samples.

Owner and Location of Deposit.	Character of Gravel.					Mechanical Analysis.															Tensile Strength of 1:3 mortar.	
	Composition of Pebbles. Per cent. of.			Proportion of Gravel to Sand, p.c. of.		Gravel. Per cent. retained on screens.							Sand. Per cent. retained on sieves.									
	Durable.	Intermediate.	Soft.	Gravel.	Sand.	2½"	2"	1½"	1"	¾"	½"	¼"	8	11	20	26	48	(Passing 48) 100	200	Passing 200	7 days.	28 days.
On road allowance, Sec. 18 T. 10 R. 19 Mun. of Cornwallis	20	80	....	35	65	......	....	....	..	...	35	65	20	5	....	10	10	40	2	3	224	270
City of Brandon pit, Sec. 16 T. 10 R. 19 Mun. of Cornwallis	35	65	....	15	85	....	....	....	....	30	25	45	10	10	....	15	40	25	0	0	97	163
Cummings and Dobbie, near King George school, Brandon, Man	...	..	.	45	55	....	.	...	....	20	25	55	30	20	....	15	10	25	0	0	297	338
City of Brandon pit, NE. part of city of Brandon	...	....	...	35	65	....	...	....	..	...	35	65	35	30	....	15	10	10	0	0	298	343
Dinsdale pit, 10th E. and Victoria Ave., Brandon, Man	30	70	...	35	65	(N part of pit)			....	...	55	15	20	15	..	20	25	20	0	0	222	394
				10	60	(S part of pit)			....	30	30	40	30	20	...	15	10	25	0	0	292	343
On right-of-way between Secs. 2 & 3 T. 10 R. 19 Mun. of Cornwallis	...	....	....	35	65	......	....	....	...	..	25	75	25	35	....	30	10	0	0	0	213	246
On right-of-way, between Secs. 5 & 6 T. 10 R. 18 Mun. of Cornwallis	...	. .	......	25	75	.....	..	.....	..	...	35	65	25	25	...	20	15	15	0	0	209	270
Wm. Portefield, R. R. No. 1, Brandon, Man., Sec., 16 T. 9 R. 19 Mun. of Cornwallis	50	50	...	25	75	......	....	. .	....	35	10	55	45	15	...	10	10	20	0	0	241	284
On right-of-way, cor. of Secs. 23, 24, 25 & 26 T. 9 R. 18 Mun. of Cornwallis	......	...	....	20	80	.....	....	. .	....	...	30	70	15	30	...	20	25	10	0	0	252	309

Results of Tests on Gravel Samples.

ALBERTA (ROCKY MOUNTAINS PARK).

Location of Deposit.	Character of Gravel.					Mechanical Analysis.													
	Composition of Pebbles. Per cent of.			Proportion of Gravel to Sand. Per cent of.		Gravel. Per cent retained on screens.							Sand. Per cent retained on sieves.						
	Durable.	Intermediate.	Soft.	Gravel.	Sand.	2½"	2"	1½"	1"	¾"	½"	¼"	8	14	28	48	100	200	Passing 200
Banff-Kananaskis road, from pit on south side of road at mile 29..	0	100	0	70	30	...	...	...	15	15	25	45	60	15	5	5	5	5	5
Banff-Kanan road, from face of cut, north side of road near old lime kiln at the "Gap" near mile 20....	0	100	0	50	50	.....	....	5	15	10	25	45	25	15	15	20	15	5	5
Banff-Kanan road, C.P.R. pit, north side of road and west end of the "Gap" Siding........	0	100	0	40	60	....	..	10	20	10	25	35	15	10	10	30	20	10	5
Banff-Kanan road, from face of sidehill cut about 1½ miles west of the "Gap"........	0	100	0	50	50		...	5	25	15	20	35	25	10	10	30	25	5	0
Banff-Kanan road, pit at top of hill on north side of road at mile 103.	0	100	0	50	50	.	5	10	10	15	20	40	35	20	10	15	10	5	5
Banff-Kanan road, pit on north side of road at top of small hill, mile 8½......	0	100	0	65	35	...	.....	5	10	25	30	30	25	15	15	20	15	5	5
Banff Kanan road, from side cut on hill at mile 7...	0	100	0	55	45	.....	...	5	15	15	30	35	20	15	15	20	10	10	10
Banff-Kanan road, from large clay banks east of Anthracite........	0	100	0	25	75	...	.	...	25	20	25	30	10	25	20	15	10	10	10
Banff-Kanan road, from big hill west of Anthracite..............	0	100	0	65	35	..	5	20	25	10	20	20	20	15	15	25	15	5	5
Beach gravel, Lake Minnewanki, Banff..................	0	100	0	95	5	....	....	.....	..	5	25	75	75	25	0	0	0	0	0
Bankhead road, pit west of entrance to Buffalo Park.... ...	0	100	0	60	40	.....	5	15	20	15	20	25	30	15	15	15	5	10	10

Results of Tests on Gravel Samples—*Concluded.*

BRITISH COLUMBIA.

Location of Deposit.	Character of Gravel.					Mechanical Analysis.													
	Composition of Pebbles. Per cent of.			Proportion of Gravel to Sand Per cent of.		Gravel. Per cent retained on screens.							Sand. Per cent retained on sieves.						
	Durable.	Intermediate.	Soft.	Gravel.	Sand.	2½"	2"	1½"	1"	¾"	½"	¼"	8	14	28	48	100	200	Passing 200.
Cranbrook district, gravel from 1st pit, 8 miles east of Cranbrook....	40	45	15	60	40	...	...	10	15	10	20	45	55	15	5	5	5	5	15
Cranbrook district, gravel from 2nd pit, 9 miles east of Cranbrook..........	40	45	15	55	45	....	.	5	25	10	20	40	55	30	10	5	0	0	0
Fernie district, from Morrisey Hill along side of the main road.	20	75	5	70	30	*30	5	5	15	10	15	20	30	20	15	20	10	3	2
Fernie district, Morrisey pit, about 8 miles west of Fernie...........	5	40	55	40	60	.	...	5	20	10	20	45	30	15	15	15	15	5	5
Trail district, pit 3 miles west of Nelson	0	85	15	50	50	....	.....	.....	15	15	20	50	45	25	10	5	5	5	5
(Gravel from preceding deposit after being in the road-bed for three years)................	.....	.....	.....	15	85	.....		.....	15	10	15	60	15	15	15	15	15	10	15
Kamloops district, Shuswap road, 10 miles east of Kamloops.......	5	20	75	50	50	15	5	5	15	10	20	30	30	25	25	15	5	0	0
Nicomen Slough gravel, from stock pile across river from Mission...	25	50	25	45	55	.....	......	....	5	5	20	70	45	20	10	10	5	5	5
Johnson Road gravel pit, on Yale road east of Vancouver..	0	70	30	25	75	..	.....	5	15	15	25	40	10	10	25	45	5	2	3

* Aggregates of small pebbles firmly cemented together by carbonate.

(WINNIPEG-BRANDON HIGHWAY.)

Location	Type.	Character. Per cent of: Clay & Fine Silt—Particles less than 0·01 mm. in diameter.	Silt—Particles between 0·01 and 0·07 mm. in diameter.	Sand-Particles more than 0·07 mm. in diameter.	Percentage of the sand retained on 65-mesh sieve.	Physical Properties: Compressive Strength (Dry).	Bearing Strength (Wet).	Remarks.
Headingly to Pigeon Lake, general type of soil.	Gumbo.....	100	0	0	0	1500	7	Black, hard surface when dry, with prominent shrinkage cracks. Surface softens, swells and gets sticky when wet, finally becoming a soft very sticky mass.
River bank, 2 miles east o St. Francis. Typical soil deposited by the Assiniboine River.	Silty loam..	25	45	30	0	850	12	Dark brown, hard surface when dry. When wet, the surface softens rapidly and gets sticky, finally becoming a soggy, sticky mass.
River bank, Bennett's farm. 2 miles east of St. Francis. Sand bar.	Sand.......	0	10	90	15	...	...	
West of Pigeon Lake. Road crosses stretches of a silty soil, probably deposited by Assiniboine River.	Silty loam..	50	50	0	0	990	5	Brownish-grey, hard, gritty surface when dry, with slight tendency to abrade to loose material. Softens when wet and gets sticky.
From road, 10 miles east of Poplar Point. Probably a river deposited soil.	Silty loam..	35	40	25	10	980	7	Dark brown, smooth hard surface when dry, with some cracks. Gets soft quickly when wet, becoming soggy and very sticky.
River bank at Belcour Ferry. Soil deposited by Assiniboine River.	Silty loam..	10	75	15	0	650	3	Brownish-grey surface, firm when dry but easily loosened into fine sand. Surface softens when wet but does not become sticky.
River bank at Belcour Ferry. Sand bank.	Sand......	0	10	90	75	...	...	
From road 4½ miles east of Poplar Point. A silty soil.	Silty loam..	55	40	5	0	830	8	Brownish-grey, smooth, hard surface when dry with considerable cracking. Surface softens when wet becoming swollen and very sticky.
From road 16½ miles east of Poplar Point, subsoil under top layer of few feet of black soil.	Yellow, clayey silt.	25	45	30	10	1370	8	Light grey, smooth, hard surface when dry, with slight cracks. When wet, surface softens, getting very sticky.
Typical top soil, east of Poplar Point.	Sandy loam	15	20	65	20	850	14	Black, hard, gritty surface when dry, with considerable cracking. Surface softens when wet but does not get sticky.
From road 1½ miles east of Poplar Point. Top soil.	Silty loam..	35	35	30	10	1010	7	Dark grey, hard gritty surface when dry, with considerable cracking and breaking out of lumps. When wet, surface softens and become fairly sticky.
From road 12 miles east of Portage, Subsoil below top layer of black loam.	Yellow, clayey silt.	45	45	10	0	1200	6	Light greyish-brown, hard, smooth surface when dry, with considerable cracking. Surface softens when wet and becomes sticky.

(WINNIPEG-BRANDON HIGHWAY—*Continued.*

Location.	Type.	Character. Per cent of Clay & Fine Silt—Particles less than 0·01 mm. in diameter.	Silt—Particles between 0·01 and 0·07 mm. in diameter.	Sand—Particles more than 0·07 mm. in diameter.	Percentage of the sand retained on 65-mesh sieve.	Physical Properties. Compressive Strength (Dry).	Bearing Strength (Wet).	Remarks.
From road 5 miles east of Portage. Yellow subsoil.	Yellow, silty sand.	10	30	60	60	700	8	Brownish-grey, hard, gritty surface when dry, with slight tendency to give loose material on abrasion. Surface softens when wet but does not become sticky.
From road 1 mile west of High Bluff. Sandy top soil.	Sandy loam.	15	35	50	40	750	4	Black, hard, gritty surface when dry, with decided tendency to break into loose material. Softens when wet but does not become sticky.
From road 7 miles east of Portage. Top soil.	Sandy loam.	15	25	60	45	......	7	Dark grey to black surface when dry, easily broken into loose material by pressure. Surface softens when wet but does not become sticky.
From road near eastern limit of Portage. Top soil.	Medium heavy clay loam.	30	40	30	0	1750	10	Black, hard surface when dry but cracked badly, which gives a tendency for surface to break out into lumps. Surface softens when wet but does not become sticky.
From road near eastern limit of Portage. Yellow subsoil.	Yellow, clayey silt.	50	50	5	0	1540	3	Grey, hard gritty surface when dry, with slight cracking. Surface softens when wet, becoming very sticky.
Snider's brick yard, east side of Portage. Top clay.	Clay loam..	40	60	0	0	1400	7	Grey, hard, gritty surface when dry, with considerable cracking. Softens and swells when wet, becoming very sticky.
Snider's brick yard. Yellow subsoil.	Yellow clayey silt.	70	30	0	0	1330	5	Light grey, hard, slightly gritty surface when dry, with a little cracking. Softens and swells when wet becoming very sticky.
Snider's sand pit. Near clay pit.	Sand......	0	0	100	85	......	....	
Fairly heavy loam from near Portage. Typical of loam in this neighbourhood.	Clay loam..	65	10	25	30	1150	6	Black, hard, gritty surface when dry, much cracked, breaking into lumps. Softens when wet and gets sticky.
From road at turn to west, 1½ miles west of Portage. Typical light loam.	Sandy loam.	10	25	65	40	570	5	Dark grey to black surface easily broken into loose material by pressure. Softens but does not get sticky when wet.
From road, 14 miles east of McGregor. Top soil.	Medium heavy clay loam.	30	40	30	0	1060	16	Black, hard, gritty surface when dry, with much cracking. Softens when wet and gets fairly sticky.
From road, 12 miles east of McGregor. Top soil.	Silty loam..	50	50	0	0	350	6	Black, fairly hard, gritty surface when dry, which is rather easily worked loose into loose material. Softens when wet but does not get sticky.

(WINNIPEG-BRANDON HIGHWAY.)—*Continued.*

Location.	Type.	Character. Per cent of: Clay & Fine Silt—Particles less than 0·01 mm. in diameter.	Silt—Particles between 0·01 and 0·07 mm. in diameter.	Sand—Particles more than 0·07 mm. in diameter.	Percentage of the sand retained on 65-mesh sieve.	Physical Properties: Compressive Strength (Dry).	Bearing Strength (Wet).	Remarks.
From road going north, from Bagot. Near main road, clayey subsoil.	Silty clay ..	50	45	5	0	1080	8	Light grey, slightly gritty, hard surface, when dry, with considerable cracking. Surface swells and softens when wet and gets very sticky.
From road, 6 miles east of McGregor. Top soil.	Sandy loam.	5	5	90	0	150	26	Dark brown to grey, gritty surface, with decided tendency to break into loose material. Surface softens a little when wet but does not get at all sticky.
From road, 1½ miles east of McGregor. Subsoil.	Clayey silt..	20	15	65	0	630	13	Light grey, hard, gritty surface when dry, with slight tendency to work into loose material on abrasion. Softens when wet but does not get sticky.
From road, 1½ miles east of McGregor. Top soil.	Silty loam..	20	20	60	0	950	35	Dark grey to black, very hard, gritty surface when dry. Takes considerable wetting to make any noticeable softening. Does not get at all sticky.
From road, ½ mile east of McGregor. Top soil.	Sandy loam.	20	20	60	0	360	7	Dark grey, gritty surface when dry, with tendency to break into loose material. Softens when wet but does not get sticky.
From road west of McGregor. A typical top soil	Silty loam..	15	55	30	0	660	6	Dark brown, hard, gritty surface when dry, with tendency to break into loose material. Softens when wet but does not get sticky.
From road in the hills west of Austin. Subsoil.	Stratified silt.	50	50	0	0	740	4	Light brown to yellow, hard, slightly gritty surface with slight tendency to break into loose material. Softens when wet and gets very sticky.
From road in hills east of Sidney. Top soil.	Sandy loam.	10	10	80	5	130	17	Dark grey, gritty surface, with tendency to break into loose material. Softens a little when wet but does not get sticky.
From brick-yard at Sidney. Top soil.	Silty loam..	15	40	45	0	740	4	Black, hard, gritty surface when dry with much cracking. Gets very sloppy when wet but not very sticky.
From brick-yard at Sidney. Subsoil.	Stratified silt.	65	35	0	0	1120	6	Brown, hard, smooth surface when dry, with much cracking. Softens and gets very sticky when wet.
From road 3 miles east of Carberry. Drift sand on surface of soil.	Sand.......	0	5	95	60	0	12	Brown, very gritty surface when dry, quite firm but easily abraded into loose sand. Softens when wet but does not get sticky.

(WINNIPEG-BRANDON HIGHWAY)—*Continued.*

Location.	Type.	Character. Per cent of Clay & Fine Silt Particles less than 0·01 mm. in diameter.	Silt—Particles between 0·01 and 0·07 mm. in diameter	Sand—Particles more than 0·07 mm. in diameter.	Percentage of the sand retained on 65-mesh.	Physical Properties. Compressive Strength (Dry).	Bearing Strength (Wet).	Remarks.
From road, 2 miles east of Carberry. Subsoil.	Silty clay...	50	25	25	0	1400	19	Brown, hard, gritty surface when dry, with some cracking. Softens when wet and gets very sticky.
From old pit for brick-making ½ mile east of Carberry. Subsoil.	Silty clay...	30	40	30	0	1110	11	Greyish-brown, hard smooth surface when dry, with considerable cracking. Softens when wet and gets very sticky.
From old pit, ½ mile east of Carberry. Top soil.	Sandy loam.	15	40	45	30	350	11	Black, fairly firm surface when dry but easily worked into loose material. Softens when wet but does not get sticky.
From road 2 miles west of Carberry. Subsoil.	Silty sand ..	5	15	80	15	390	19	Brown to grey, hard, gritty surface when dry, not easily worked loose but with a tendency to break out. Softens somewhat when wet but does not get sticky.
From road through sand dunes, 1 mile east of Camp Hughes.	Sand.......	5	5	90	50	150	11	Dark, fairly firm surface when dry, but easily broken into loose sand. Soft when wet but not sticky.
From road west of Camp Hughes. Top soil.	Sand.......	5	10	85	75	200	13	Black, fairly firm surface when dry, but easily broken into loose material. Softens when wet but does not get sticky.
From road between Camp Hughes and Douglas. Top soil.	Sandy loam	10	10	80	60	370	10	Dry surface dark grey, with no strength at all, breaking into loose material with least pressure. Does not get sticky when wet.
Subsoil from near Douglas.	Silty sand...	10	10	80	65	140	12	Grey, gritty surface when dry, with considerable cohesion, but easily worked loose. Does not get sticky when loose.
From road between Chater and Brandon. Subsoil.	Silty clay ..	45	30	25	0	1090	4	Light brownish-grey, hard, gritty surface when dry, with considerable cracking; softens and swells when wet and gets very sticky.
From road between Chater and Brandon. Top soil.	Sandy loam	10	45	45	50	410	10	Black, dry surface has no coherence; breaks easily to loose material. Does not get sticky when wet.
From escarpment of Assiniboine river, near the asylum, Brandon. Subsoil.	Silty sand .	10	20	70	10	440	9	Light grey, very gritty, hard surface when dry, with a slight tendency to work into loose material. Does not get sticky when wet.

(WINNIPEG-BRANDON HIGHWAY.)—*Continued.*

Location.	Type.	Character. Per cent of: Clay & Fine Silt—Particles less than 0·01 mm. in diameter.	Silt—Particles between 0·01 and 0·07 mm. in diameter.	Particles more than 0·07 mm. in diameter.	Percentage of the sand retained on 65-mesh sieve.	Physical Properties. Compressive Strength (Dry).	Bearing Strength (Wet).	Remarks.
Columbia District. Road running south from Golden. Silt from cliffs along the road at Upper Columbia Lake.	Silt	100	0	0	0	160	55	Dry surface light grey, smooth, with soapy feel. Surface does not seem very firmly cemented together but is not easily worked loose. When wet, a greasy layer develops on surface but mass as a whole does not soften. Prolonged wet makes mass become rubbery but not sticky. Surface is always very slippery when wet.
Cranbrook District. From Cranbrook-Fernie road, 9 miles east of Cranbrook. Silty soil.	Silt	60	40	0	0	330	100	Dry surface light greyish-brown, hard and smooth. Surface is not very firmly cemented but does not seem easily worked loose. Prolonged rain softens the mass slightly giving it a rubbery feel but it never gets sticky or slippery.
Trail District. From Nelson-Brilliant road; fairly typical soil from near Nelson.	Silty sand	15	20	65	75	240	7	Dry surface light brown, with very little coherence; easily broken into loose material. When wet, surface gets very soft, holding excess water and tends to get into a sort of batter. Does not get sticky.
Okanagan District. From silt cliffs along the lake on Penticton-Kelowna road.	Silt	80	20	0	0	520	5	Dry surface grey, smooth and hard. When wet, surface softens and gets quite sticky.
Kamloops District. From Kamloops-Shuswap road. Silty soil at Currie Gulch.	Silt	70	25	5	0	430	3	Dry surface grey, smooth, but easily worked into loose material. When wet, it becomes very soft and somewhat sticky. Mass gets like soft rubber. Deforming action of pressure is visible far from point of application. This soil has decided tendency to get into a batter and run.
Kamloops District. From Kamloops-Shuswap road, 20 miles east of Kamloops.	Silty sand	10	20	70	60	460	60	Dry surface dark coloured, gritty and quite firm; takes considerable abrasion to loosen surface. When wet, surface softens but does not get sticky.

Results of Tests on Samples of Decomposed Rock from British Columbia.

Location.	Compressive Strength (Dry).	Bearing Strength (Wet).	Remarks.
Decomposed shale from Banff-Castle road, Rocky Mountains Park, Alta., north side of road about 14 miles west of Banff.	560	100	Dry surface dark coloured and hard. All night rain softened top half inch to quite a soft soaked condition but there was very little softening below this depth. Wet material is not sticky.
Columbia district. Decomposed shale from Johnson's road, near Invermere.	260	60	Dry surface dark grey in colour, firm and hard. Wetting softens surface but does not make it sticky.
Cranbrook district. Decomposed rock from Cranbrook-Fernie road, 7½ miles east of Cranbrook. Fairly fresh rock fragments.	250	60	Dry surface purplish-grey in colour, and hard. When wet, the surface softens but does not get at all sticky.
Cranbrook district. Decomposed rock from 7½ miles east of Cranbrook near preceding deposit. Rock fragments more weathered.	280	60	Dry surface light yellow, hard. When wet, surface softens but does not get sticky.
Cranbrook district. Decomposed rock from Cranbrook-Fernie road, 3½ miles east of Cranbrook.	390	40	Dry surface yellow in colour and hard. Surface softens somewhat when wet but does not get sticky.
Okanagan district. Talus rock from a broken up rock deposit on Penticton-Kelowna road on west side of lake before descending to the ferry landing.	780	60	Dry surface light grey in colour and hard. When wet, the surface softens and gets rather sticky.
Kamloops district. From rock talus on the North Thompson road, 9 miles north of Kamloops.	400	150	Dry surface dark grey in colour and hard. Surface is only slightly softened by wetting and does not develop any stickiness.
Kamloops district. From decomposed rock deposit on Grand Prairie road at Campbell creek.	380	35	Dry surface reddish-brown, hard. When wet, surface softens but does not get sticky.
Alberni district, Vancouver island. Sample of decomposed rock sent in by Public Works Dept., Victoria.	440	40	Dry surface red in colour and hard. When wet it softens but does not get sticky.

ALBERTA BITUMINOUS SANDS FOR RURAL ROADS.

G. C. Parker.

During 1917 and 1918, a study was made with a view to determining the possibilities of using the bituminous sands of northern Alberta as a surfacing material for rural roads. In order to collect information and data the writer visited Iowa and California in November and December, 1917, to inquire into the results obtained by the treatment of earth roads with asphaltic oils in Iowa, and the service rendered by bituminous sand surfaces in California. In April, 1918, he went to Alberta to study highway conditons in the Province. Up to the present time the bituminous sands constitute the largest mineral resources existing in the northern portion of the Province and the development of this district will depend on the extent to which the material can be used commercially. In an endeavour to open up the country, the Alberta and Great Waterways Railway has recently been completed from Edmonton to Fort McMurray, a distance of 305 miles. The development of commercial uses for the bituminous sands will not only assist in placing the railway on a paying basis but will also aid in the development of the northern part of the Province.

The largest market for asphalt has, for a number of years, been derived from the paving industry. The greater part of the paved area of the city and town streets has been surfaced with mixtures containing native or manufactured asphalt. It is natural therefore, in looking for a use for bituminous sands to consider their adapta-

bility to road surfaces. Material similar to that found in Alberta exists in many localities in the United States, that most closely resembling it being found in the state of California. As early as 1886, bituminous sand road surfaces were laid in Santa Barbara, Cal., and since that year many miles of roads have been surfaced with material from different deposits, with good, bad, and indifferent results.

Materials most commonly used for this work, stone and gravel, are not plentiful in Alberta. In isolated sections both may be found but the greater portions of the Province have no local source of suitable material. Sand, containing a comparatively small proportion of gravel occurs in a number of places but this is not of proper quality for the construction of substantial surfaces. The bituminous sand deposits must therefore be looked to in any endeavour to secure road building material.

In 1915, the Mines Branch constructed experimental surfaces with the Alberta sands, laying a section of pavement in the city of Edmonton. This has been a success and has attracted such attention that strong representations have been made, asking that experiments be extended with a view to determining the suitability of the material for surfacing country roads.

In consideration of the use of a material for this purpose, the question of cost demands first consideration. An expensive material, no matter how suitable, is not economically available. Therefore, having established the suitability of the bituminous sands for road surfaces from a technical point of view the cost of placing the material at the site of the work must be arrived at. This cost is made up of several items, namely,—cost of mining, cost of loading, cost of transportation and cost of hauling to the work. The cost of mining is governed largely by the manner in which the material occurs, as well as its character. The cost of loading depends on the proximity of the railroad to the deposits from which the material is taken and if the railroad siding enters the deposit, the method used in loading the cars. If, on the other hand the deposits lie at some distance from the railroad provision must be made for horse or mechanical haulage over this distance, with attendant cost. Transportation charges are governed by the freight rate extended by the railroad and the distance over which the railroad transports the material.

From reports previously published by the Mines Branch it is shown that the deposits lie in an area, the southern portion of which is approximately three hundred miles north from Edmonton. They are found, for the most part along the banks of rivers and creeks. The depth of the material as well as the thickness of overburden varies greatly. The limits of this variation may be illustrated by two deposits, one of which consists of an exposed bed of bituminous sand 50 feet thick underlying 205 feet of top soil; the other having only 15 feet of overburden on a bed of bituminous sand 180 feet thick. The cost of stripping the overburden must be added to the cost of removing the material from the deposit. Where possible, therefore, development should be confined to the heavy deposits with light overburden since the removal of the minimum of unusable material will permit the removal of the greater amount of that which is suitable. Regard must be had, however, for the quality of the material before deciding on which deposits to open. Since it is the asphalt contained in the bituminous sand that is of value and since this varies from 9 to 20 per cent of the total material, with an approximate average for all the deposits of 14 per cent, the economic balance between the costs of quarrying a low grade material from a deposit with light overburden and that of removing a high grade material from under heavier overburden must be struck. This not only affects the cost of quarrying, but that of transportation. A ton of material containing 20 per cent of bitumen will cost about the same to quarry and transport as a ton of bituminous sand containing 10 per cent. In the first case it requires but 5 tons of the crude material to make one ton of asphalt, while in the second, 10 tons would have to be handled to obtain the same amount of bitumen.

From maps published it is seen that the upper end of the Alberta and Great Waterways railway penetrates the area in which the deposits are located and for several miles

it runs practically through the more southerly of these. The question of proximity of railroad shipping points should not be serious. Short spurs could be constructed from the main line of the railroad right to the face of the deposit, thus insuring cheap loading.

Little can be said with regard to the cost of transportation from the deposits to a point where material would be used. Until the exact points of shipment, as well as the estimated quantity of material that will be carried has been decided upon, it will not be possible to obtain the actual cost for freight.

Past experience has established two governing factors in the successful construction of asphaltic road surfaces. Not only must the bituminous binder be of the proper consistency but it must exist in the proper proportion, this proportion being dependent on the mechanical grading of the mineral aggregate. A mixture containing a fine sand can carry more asphalt than one containing coarse. Then again, the various sizes of grains must be present in relative proportions. Most consistent success has been attained with a mixture known as the standard sheet asphaltic mixture which has the following physical composition:—

Material.	Percentage by weight.
Bitumen	10·5
Passing 200-mesh	13·0
" 100 "	13·0
" 80 "	13·0
" 50 "	23·5
" 40 "	11·0
" 30 "	8·0
" 20 "	5·0
" 10 "	3·0
Total	100·0

Analyses of samples taken from the Alberta deposits show that it will be almost impossible to secure a uniform supply of material with the above composition and that the mixture of materials of different grades will be necessary.

That this can be accomplished has been shown in the construction of the Edmonton pavement in which two grades of bituminous sands were successfully used. One was coarse in composition and contained 12 per cent of bitumen while the other, containing 16 per cent of bitumen, was very fine. These were heated and mixed in specified proportions and to them was added dry sand of the proper grading and in sufficient quantity to modify the resultant mixture in accord with the standard. Then again the character of the impregnating bitumen was not entirely suitable, as it was too soft. It was found that by retaining the material in the heated mixing chamber for a few moments the driving off of the lighter oils resulted in a hardening of the asphalt. The materials were mixed and heated in batches, each batch was dumped on the concrete foundation and spread and rolled while hot.

Three types of surface mixture were used. The sheet asphalt mixture contained the bituminous sands and dry sand; the asphaltic concrete contained in addition to the bituminous sand and dry sand a certain proportion of gravel; and a mixture approximating that called for by the bitulithic specifications resembled the asphaltic concrete differing from it in the grading of the mineral aggregate.

The following analyses of the mixtures as they entered the road, as well as the analyses of samples cut from the pavement in 1918, by the writer, are shown below. When compared with the composition of the original bituminous sand, it will be seen that it is quite possible to obtain results similar to although not identical to those secured with manufactured imported asphalts. While the pavement has been under traffic for only three and a half years, which does not justify comparison with others laid at earlier dates, up to the present it compares favourably with similar surfaces of wholly artificial mixtures.

BITUMINOUS SAND.—ANALYSES OF MIXTURES LAID IN EDMONTON IN 1915.

(Percentage by weight.)

Material.	Sheet Asphalt.		Asphaltic Concrete.		Bitulithic.	
	1915	1918	1915	1918	1915	1918
Bitumen	11·3	11·0	9·1	9·1	8.1	7·3
Passing 200 mesh	9·0	9·0	3·9	5·0	5·2	5·0
" 100 "	......	21·0	......	19·0	......	12·0
" 80 "	33·0	14·0	42·1	11.0	37·0	9·0
" 50 "	13·7	25·0	4·2	15·0	......	9·0
" 30 "	13·5	5·0	0·3	......	......	4·0
" 20 "	12·5	7·0	0·8	1·0	8·1	5·0
" 10 "	7·0	8·0	4·0	4·0	6·7	7·0
" ¼ inch	0·5	......	......	10·0	......	7·0
" ½ "	......	......	35·3	26·0	......	12·0
" 1 "	......	......	......	......	34·7	22·6
Totals	100·5	100·0	99·7	100·1	99·8	99·9

Bituminous Sand Surfaces in California.

From 1886 until 1914, the bituminous sand deposits of California were used as a source of paving material, and while a number of the surfaces are in service at present probably an equal or greater number were failures. Prior to 1909, it was customary to heat the crude material in kettles, and lay it in the same manner as that used with artificial mixtures. The lack of uniform results led to an investigation and an improved method of treating the material. It was found that the natural grading and proportioning in most cases was not suitable and that the addition of dry sand was required to produce a mixture approaching the standard. It was also necessary to heat the bituminous sand for some time in order to harden it by the driving off of the lighter constituents of the asphalt, and a special form of mixer was designed for this purpose. Following the adoption of the improved methods consistent results were produced and practically all the surfaces laid with the graded mixtures are to be seen to-day.

While in California the writer examined a total of 28 bituminous sand surfaces, and procured information concerning 12 others. Of these, 21 were constructed of crude material and 19 consisted of the graded mixtures of sheet asphalt and asphaltic concrete. The results of 46 tests were recorded and many more studied, those of which copies were made being representative of the total number examined.

It is significant to note that of the 21 crude surfaces, 6 were failures and 3 were indifferently good, while of the 19 graded mixtures there was reported only one failure, and this was on account of the specifications not being followed. The analysis of this surface furnished sufficient indication to show the reason for the failure. The results secured show without a doubt that the bituminous sands when properly treated have been a success. In the cases where the crude material had been used satisfactorily results of tests showed mixtures which, while not closely resembling the standard, at least were better balanced with regard to the relation of fine sand to coarse, and sand to bitumen. In two instances pavements which had failed appear to have compositions similar to those of others which had not. The explanation given was that the material had not been heated properly and consequently the asphalt was too soft.

A number of pavements have been laid with what is termed the "black" base, meaning a foundation of asphaltic concrete in which the bituminous sands were incorporated, with or without a sheet asphalt surface. In the town of Hayward, two

of the main business streets were surfaced, in 1911, with 3½ and 4 inches of asphaltic concrete and 1 inch of sheet asphalt. York and Virginia streets in Vallejo were paved between the years 1907 and 1910, the pavements consisting of one layer of asphaltic concrete 5 inches thick. The Santa Barbara-Goleta road, 8 miles long, was built in 1912 with 3½ inches of asphaltic concrete and 1½ inches of sheet asphalt. The above surfaces were examined by the writer and found to be in almost perfect condition. In one instance the settlement of the subgrade had caused cracks and depression in the surface but the total area of these defects would not exceed 50 square yards. The mixtures used were carefully graded, the unbalanced composition of the crude material being compensated for by the addition of dry sand and crushed stone in proper proportions.

In considering the success of the above surfaces sight must not be lost of the difference in climates between California and Alberta. In the former frost is not frequent, and heavy, continued freezing is unheard of; while at Edmonton the average mean monthly temperature range, over a period of 24 years, was from –3·2 degrees in January to 73·7 degrees in July. The action of frost must therefore be minimized by special care in the drainage.

In this connexion it is interesting to note that in the state of Iowa, where the climate is similar to that of Ontario, although not as severe as that of Alberta, certain success has been attained by the waterproofing of the road surface by treatment with asphaltic oils. A number of roads have been rendered not only passable but quite firm and smooth for twelve months of the year by two applications of oil. Several of these roads were seen by the writer in the winter of 1917, during a mild period, immediately succeeding one of snow and frost. In every case but one the surface was smooth and hard, the one exception being a sand road which derived little benefit. The best results have been obtained with heavy black clay which, to all appearances at least, is similar to the dark soil of the Canadian West.

Until 1918, highway expenditure in Alberta was made by the Provincial Government as directed by the Minister of Public Works, the Government meeting the entire cost. Last year, however, a comprehensive scheme for improvement was undertaken and as a first step all roads are to be classified in "main", "district", and "local". Towards the cost of the main roads, the Government contributes 75 per cent, 25 per cent towards the cost of district roads, and nothing in connexion with the local roads. The local municipalities contribute the remaining 25 and 75 per cent towards the cost of the main and district roads and bear the entire expense of construction of the local roads. In this way the Province has the responsibility for the construction and maintenance of the trunk highways and is interested to a smaller extent in the other branches of the system. Thus if the construction of experimental rural roads with the bituminous sands were undertaken such surfaces could be laid by the Province on the heavily travelled roads, where they would be subjected to a severe test, at a comparatively small cost to the municipalities.

As might be expected, soil conditions vary. Practically all of the roads in the Province have earth surfaces. Consequently different methods of treatment have been found necessary. A clay road cannot be too dry and once thoroughly dried it will remain hard and firm during a wet period in the summer. A sand road, when quite dry is soft and the surface easily displaced, and the water penetrates to a greater extent and takes longer to evaporate. Its surface is never firm and hard while that of a dry clay road will bear heavy wheel loads and will not break up until the subgrade is saturated. It will, however, become muddy and slippery during a rain. The greater mileage of the Alberta roads is through the heavy clay, but roads were also seen on sandy and chalky soils.

The work done by the Provincial Road Department in the past has been quite effective. The first principle of road construction, proper drainage, has been strictly followed and in travelling over the roads which have been improved, one is impressed

with the success attained. In many instances difficulty was encountered as parts of the country are flat and are dotted with water holes. These have been drained, the expenditure in the construction of long ditches having been considerable.

Most of the main roads are so located with respect to the supplies of road-building materials that they can only be secured at great cost. Stone is found at the foothills of the mountains but the cost of transportation added to the cost of quarrying will render its general use prohibitive. Gravel is found in restricted areas and is not of a quality best adapted to road surfacing. The bituminous sands can be obtained by direct haul from the deposits on a new railroad not overburdened with traffic. The management of the Alberta and Great Waterways railway has indicated its desire to co-operate in the development of the deposits to the extent of furnishing a low freight rate from McMurray to Edmonton.

It has been shown that the bituminous sands have been successfully used, both in California and Alberta, for surfacing roads with rigid foundations, provided the physical composition on the surface mixture were regulated. In California one layer of bituminous sand mixture has carried traffic for ten years and only where the subgrade was weak did the surface break. In Iowa the draining of the subgrades and the waterproofing of the surface of clay roads have given excellent results, provided that the treatments were repeated and that drainage was maintained. In Alberta it has been demonstrated that the serviceable period of the earth roads can be greatly lengthened by the installation of effective drainage. It is therefore reasonable to expect that the addition of waterproof coating to the surface of these roads will provide a dry subgrade and a firm surface during prolonged wet periods. This could be done by introducing a small quantity of the crude bituminous sand into the surface of the clay roads.

Better results although at greater cost, might be expected from an asphaltic concrete mixture laid on a well drained, compacted subgrade and rolled to a thickness of 4 or 5 inches. Since the success of such a pavement will depend on the subgrade being free from water, particularly at a time preceding a heavy frost, special attention to the drainage will be required.

A total of 6,600 tons of bituminous sand will furnish sufficient material to surface with asphaltic concrete mixtures 2 miles of road, 10 feet wide and 4 inches thick, 2 miles, 10 feet wide and 5 inches thick, and 3 miles with a waterproofing surface 10 feet wide. The cost of laying the 6,600 tons mentioned above, exclusive of plant charges, should not exceed $35,000, of which about one-half would be for quarrying, loading, and transporting, with a freight rate of $1 per ton. This figure can, however, be but an approximate estimate of the cost of the work.

There is reason to believe that it will be possible to use the Alberta bituminous sands with success in the construction of rural roads. The writer would beg to suggest that the Mines Branch co-operate with the Provincial authorities in a plan for giving this material a practical trial in types of rural construction such as have been indicated. The Mines Branch should make a careful examination of soils and available materials for use in conjunction with the bituminous sand along stretches of road suitable for experimental purposes and determine upon a plan of procedure. When a mutually satisfactory programme has been decided upon, the Provincial Highway Department should take the responsibility of financing and of providing engineering direction, granting to the Mines Branch, however, supervision in so far as the use of materials is concerned.

References to the reports by S. C. Ells on the Investigation of the Bituminous Sands of Northern Alberta.

1. Summary Report, Mines Branch, 1915, page 69.
1916, " 56.

2. Summary Report, Mines Branch, 1913, page 54.
1915, " 68.

Preliminary Report on the Bituminous Sands of Northern Alberta, Mines Branch, 1914, pages 11 to 37.

3. Summary Report, Mines Branch, 1913, page 54.
1915, " 68.

Mr. Ells has prepared a file of maps showing the topography of the surrounding country and the location of outcrops of bituminous sand in the McMurray, Clearwater, Christina, Steepbank, McKay, and Moose areas of the general area over which the outcrops of bituminous sand occur. These maps are available for reference at the Mines Branch.

4. Summary Report, Mines Branch, 1914, page 62.

Preliminary Report on the Bituminous Sands of Northern Alberta, Mines Branch, 1914, page 79.

DIVISION OF CHEMISTRY.

SUSSEX STREET LABORATORY.

F. G. WAIT, *Chief of the Division.*

The work done in the laboratory during the year ending December 31, 1918, may be classified as under:—

ASSAYS FOR GOLD, SILVER, AND PLATINUM: From the undermentioned localities in:—

(*a*) *British Columbia.*

i. Headwaters of Whitewater creek, Ainsworth Mining Division.
ii. West shore of the middle channel of Barclay Sound.
iii. Broken Hill property, Rapid creek, Lardeau River valley.
iv. From a point 8 miles north of Lewis Creek station (C.N.R.), north of Kamloops.
v. An undefined point 8 miles south of Sicamous, and 40 miles from the Sicamous-Vernon branch of the C.P.R.
vi. A sample of New Hazelton gold-cobalt ore.
vii. Concentrates from the Quesnel Hydraulic Gold Mines, at Hydraulic, Cariboo Mining Division.
viii. From placer workings on Wild Horse creek, near Fort Steele.
ix. From an outcrop on the shore of Powell lake.
x. From the Jo Jo mineral claim, Slocan district, West Kootenay.

(*b*) *Manitoba.*

24 samples from the Star Lake district.

(*c*) *Ontario.*

i. Thunder Bay district:—
One sample from the shore of Atik lake, near Port Arthur.
One from a point 30 miles east of the mouth of Pigeon river; and four others from the vicinity of Long lake.

ii. Timiskaming district:—
Hislop township—Lot 1, con. IV, one sample; and one sample from undesignated localities in each of the following townships: Bucke, Cleaver, Coleman, and Powell.

(*d*) *Quebec.*

i. Pontiac county:—
Three samples from lot 28, r. VI, of Clarendon township, and three others from undesignated localities in Onslow township.

(*e*) *Nova Scotia.*

i. Halifax county:—
Concentrates—two samples from the property of Scheelite Mines, Ltd., Moose River mines.

ii. Richmond county:—
One sample from the Sterling zinc deposit.

In addition to those enumerated above, there were 18 samples concerning which no data as to locality of occurrence were furnished.

Antimony Ore: One sample of stibnite from Fish creek, a tributary of the Klondike river, Yukon territory.

Chrome Iron Ore: Three samples from a correspondent in Rossland, B.C. Precise locality not stated.

Clay—and Sediments: Three samples taken from the bottom of lake Ontario, at depths ranging from 10 to 600 feet.

Copper Ore: One sample from lot 1, con. VI, of Lorne township, Sudbury district, Ontario.

Ferro-silicon: Fifty-two samples of this material, all of high silicon content, were analysed for the Imperial Ministry of Munitions. This work—a continuation of that reported last year—was carried on by members of our own staff until May, 1918.

Fireclay: One sample from Missinaibi river, north of Coal brook, Algoma district, Ontario.

Glass Sand: Twenty-one samples of quartz sand have been submitted to partial analysis to ascertain their suitability for employment in glass manufacture. Special attention was given to the determination of the usual deleterious constituents—iron, alumina, lime, and magnesia.

The following localities have been visited and samples taken:—

Quebec.

Beauharnois county:—
- Melocheville, from the quarry of Montreal Sand and Gravel Co.
- Beauharnois, from the farm of W. H. Robarts.

Chateauguay county:—On north and south road, 4½ miles north of Ormstown.

Huntingdon county:—
- Covey Hill, from farm of Charles Brisbin. On main road between Hemmingford and Vicars, at a point 7 miles west of Hemmingford.
- On the east and west road, 1 mile west of Maritana, on the farm of Joseph Foyer.
- Franklin Centre, from the bottom of the east branch of Outard creek, just north of the bridge.
- On east and west road, 2½ miles west of road from Hemmingford to Barrington.

Kamouraska county:—
- SW. end of Long Pilgrim island.
- NW. " "
- 3¾ miles north of St. Pascal Station; property of Jos. Labris.
- 3 miles SE. of wharf at Kamouraska; property of Arsine Drapeau.
- 3 miles SW. of St. Pascal Station; property of Louis Migneault.
- SW. end of Great Pilgrim island.

Portneuf county:—
- Chavigny township, S. ½ lot 5, r. I, SW.; near Notre-Dame-des-Anges.
- Montauban township, lot 1, r. V., SW., and Montauban township, lot 1, r. V, NE., Notre-Dame-des-Anges.

Ontario.

Frontenac county:—Loughboro township, lot 19, con. X.
" " lots 9 and 10, con. VII.
Pittsburgh township, N. ½ lot 11, con. V.
" salmon-coloured material.

Haldimand county:—Nelles Corners, property of Oneida Lime Co.
i. Run of pit.
ii. North outcrop.
iii. North side of quarry.

Lanark county:—North Burgess township, S. ½ lot 11, con. VIII.
North Elmsley township, S. ½ lot 26, con. X.

Leeds county:—Bastard township, lot 25, con. I.
Elizabethtown township, S. ½ lot 36, con. I. From cliff on shore of St. Lawrence river.
North Crosby township, centre of lot 8, con. VII.
South Crosby township, lot 15, con. I.

Graphite and Graphitic Rock:

Two specimens of graphitic rock from Algoma district, Ontario, as follows:—
i. At C.N.R. mileage 70 and 48 chains west of Hornepayne. Graphite-bearing zone in biotite gneiss.
ii. Taradale, graphitic biotite schist. Missinaibi district, Ontario; precise locality not stated.

Identification of Material:

One hundred and twenty-one samples of different kinds have been examined during the year. In most instances the determination of mineral species was sufficient; in others an opinion as to probable economic value was required.

Iron Ore: One sample was analysed during the year. It was taken from a deposit on lot 15, con. V, of Belmont township, Peterborough county, Ontario.

Limestones: One hundred and twenty samples of limestones and dolomites were analysed to ascertain their suitability for use in various manufacturing industries. They were collected at the undermentioned localities:—

Ontario.

1. Bruce county:—
Brant township, lot 2, con. VII, Reid's quarry.
Carrick township, lot 8, con. A, an old quarry.
Culross township, Teeswater, Toronto Plaster Co's quarry.
Kincardine township—
Lots 6 and 7, con. III, Holland's quarry.
Inverhuron, Smith's quarry.
Owen Sound—
Chalmers' estate quarry, west hill.
Oliver Roger's Stone Co., east hill.
Wiarton, from an exposure on Gould street.

Carleton county:—
Gloucester township—
Lot 22, con. I, Robillard's quarry, upper 10 ft.
Robillard's quarry, lower 6 ft.
Lot 1, con. III, McLaren's quarry.
Lot 24, con. I, Gamble's quarry.
Merivale road, Rideau Canal Supply Co.'s quarry.
Hogsback, Thibault's quarry.
Goulburn township, east half lot 3, con. XII, Sullivan's quarry.
Nepean township, lot 32, con. A.
Torbolton township, lot 21, con. IV, McTernan's quarry.

Dufferin county:—
  Amaranth township, lot 32, con. I, Hall's quarry.

Dundas county:—
  Williamsburg township—
    Lot 31, con. VII, Farlinger's quarry.
    Lot 19, con. VIII.
  Winchester township, corporation quarry, ½ mile south of Winchester station.

Essex county:—
  Anderdon township, lot 6, con. I, Solvay Process Co.'s quarry.

Frontenac county:—
  Hinchinbrook township, east of Godfrey.
  Kingston township, lot 4, con. II.
  Pittsburgh township, Barriefield camp, three samples.
  Portland township, lot 9, con. XIII, McMullin's quarry.
  Wolfe island, quarry ¼ mile east of wharf.

Glengarry county:—
  Charlottenburg township, lot 6, con. X,I,L.
  Lochiel township, lots 6 and 7, con. II.

Grenville county:—
  Augusta township, lot 17, con. II.
  Wolford township, lot 2, con. I, exposure in C.P.R. cut.

Grey county:—
  Artemesia township, Eugenia Falls, upper 20 feet.

Haldimand county:—
  Cayuga North township, lot 49, con. II, Oneida Lime Co.'s quarry.
  Dunn township—
    Lot 18, con. ?, Webber's quarry, upper 10 ft.
    Lot 18, con. ?, Webber's quarry, lower 12 ft.
  Rainham township, lot 2, con. II, Helka's quarry.
  Walpole township—
    Lot 6, con. XIV, Wieger's quarry.
    Lot 1, con. XIV, Teitz's quarry.

Halton county:—
  Esquesing township—
    Lot 24, con. IV, Toronto Lime Co.'s Dolly Varden quarry.
    Lot 22, con. VI, Toronto Lime Co.'s Limehouse quarry.
  Nassagaweya township—
    Lot 3, con. VI, Christie-Henderson quarry, "buff" stone.
    Lot 3, con. VI, Christie-Henderson quarry, "blue" stone.
    Lot 3, con. VII, D. Robertson and Co.'s quarry.

Hastings county:—
  Elzevir township, quarry in village of Actinolite.
  Hungerford township—
    Lot 12, con. XIV, Hastings Quarries Co.
    Lot 12, con. XI.
  Tyendinaga township, vicinity of Shannonville, Ontario Limestone and Clay Co.'s quarry.

Huron county:—

Howick township, lot 13, con. VIII, Ashton's quarry.

Lambton county:—

Bosanquet township, weathered hand sample from R.R. cut ¾ m. NE. of Thedford.

Lanark county:—

Beckwith township, lot 12, con. X, McNeely's quarry.

Pakenham township—

Lot 23, con. XII, Duncan's quarry.

East of the village of Pakenham.

Ramsay township—

Lots 8 and 9, con. IV, Cameron's quarry.

Lot 20, con. V.

Lot 17, con. IX, north of Almonte.

Leeds county:—

Bastard township, from Delta Lime Co.'s quarry.

Crosby North township, lot 11, con. VIII; exposure on roadside, 2 m. from Westport.

Elizabethtown township—

One mile east of Brockville, on south side of Prescott road.

One-half mile east of Brockville, north of Prescott road on property of G. Sherwood.

Lennox and Addington counties:—

Camden East township, lot 13, con. I, Tompkin's quarry.

Ernestown township, lot 35, con. VII, old quarry.

Richmond township, Bergin's quarry, on Roblin's hill, east of Napanee.

Richmond township, old quarry, 2½ m. N.E. of Napanee.

Lincoln county:—

Grantham township—

Lot 15, con. X, Ball's quarry.

Lot 17, con. X, Hansell's quarry.

Niagara township—

Lots 47, 48, 49, Queenston Quarry Co., upper 18 ft.

Lots 47, 48, 49, Queenston Quarry Co., lower 15 ft.

Norfolk county:—

Woodhouse township, lot 24, con. I, Howey's quarry, upper 8 feet.

Ontario county:—

Rama township, Longford Quarry Co., Canada Iron Corporation's old quarry, ½ mile north of Longford.

Oxford county:—

Oxford West township, Standard White Lime Co.'s west quarry, near Beachville.

Peel county:—

Near Melville junction, Contractor's Supply Co.'s quarry.

Credit Forks, a hand sample.

Perth county:—
- Blanchard township—
  - St. Mary's, Standard White Lime Co.
  - St. Mary's Cement Co.

Peterboro county:—
- Belmont township, from an exposure near Preneveau.
- From a rock cut on C.P.R., 1 mile east of Havelock.

Prescott county:—
- Alfred township, lot 6, con. IV, Lett's quarry.
- Hawkesbury East township—
  - Lot 28, con. I, Ross's quarry.
  - Lot 10, con. III, Stevens' quarry.
- Plantagenet North township, lot 9, con. VI, Winning's quarry.

Prince Edward county:—
- Hallowell township, lot 23 or 24, con. III, M.T., Bedborough's quarry.
- Sophiasburg township, lot 52, con. II, W.G.P., Doxisee's quarry.

Renfrew county:—
- Bagot township, lot 28, con. VI.
- Bromley township, near Douglas station, C.P.R., McDougald's quarry.
- Grattan township, east of Eganville, Standard Chemical Iron and Lumber Co.'s quarry.
- Horton township—
  - Lot 5, con. II, Jamieson's quarry.
  - Lot 13, con. III, Jamieson's quarry.
- McNab township, lot 18, con. XIII, Canada Lime Co.'s quarry.
- Pembroke township, lot 12, con. I, Markus' quarry, 12-ft. face.
- Ross township—
  - Lot 19, con. VI, Renfrew White Granite Co.'s quarry.
  - Lot 10, con. X, Jamieson's quarry.
- Wilberforce township, lot 20, con. XIX, Biederman's quarry.

Russell county:—
- Clarence township—
  - W. C. Edwards', (Stewart's) quarry, Rockland, average of upper 75 ft.
  - F. Beauchamp's quarry at Clarence creek, average of upper 6 ft.
- Russell township, lot 7, con. VII, E. Bruyere's quarry, 2 samples.

Simcoe county:—
- Medonte township—
  - Lot 20, con. XIII, Peters' Coal Co. quarry; upper 25 ft.
  - Lot 20, con. XIII, Peters' Coal Co. quarry; lower 6 ft.
- Nottawasaga township—
  - Lot 47, con. XI, Cramp Steel Co.'s quarry near Collingwood.
  - Lot 25, con. XI, Chestnut's quarry.
- Orillia North township—
  - Lot 10, con. IV, Ontario Stone Corporation's quarry.
- Tay township—
  - Lots 19 and 20, con. V, Canada Iron Corporation's quarry; upper 5 ft.
  - Lots 19 and 20, con. V, Canada Iron Corporation's quarry; lower 8 ft.

Stormont county:—
- Finch township, lot 8, con. XII, Mackie's quarry.

Victoria county:—

Eldon township, lot 49, con. IX, Crushed Stone, Ltd., Co.'s quarry; average of 16-ft. face.

Waterloo county:—

Dumfries North township, Christie-Henderson and Co., quarry, in the city of Galt.

Welland county:—

Bertie township—

Lot 13, Lake Erie front, Standard Crushed Stone Co.'s quarry.

Lot 7, con. VIII, township quarry; lower 14 feet.

Stamford township—

Lots 31, 32, near Thorold; upper 20 ft.

Lots 31, 32, near Thorold; lower 10 ft.

Wellington county:—

Eramosa township, E. Harvey's quarry at Rockwood.

Erin township, lot 15, con. VI, Ashenhurst Bros.' quarry, average of 12-ft. exposure.

Guelph township—

Standard White Lime Co.'s quarry at Guelph.

Prison farm quarry; upper 10 ft.

Nichol township—

James Gow's quarry at Fergus.

Elora White Lime Co.'s quarry at Elora.

Puslinch township, lot 2, con. IV, Christie-Henderson Co.'s quarry, 3 miles north of Hespeler.

Wentworth county:—

Ancaster township, lot 48, con. II, Guests' quarry, upper 18 ft.

Barton township, lot 15, con. VI—

Gallagher Lime and Stone Co.'s quarry; upper 8 ft.

" " " " lower 16 ft.

" " " " 4-ft. bed of brown coursing stone.

Beverley township, lot 8, con. III, Parks Bros.' quarry.

Flamboro West township—

Lots 12-15, con. I; Canada Crushed Stone Corporation, Ltd., lower 30 ft.

Lot 6, con. VI, county quarry; average of 10-ft. face.

MANGANESE ORES: Eighteen samples have been analysed from:—

Nova Scotia—Cape Breton county, Hay cove, two samples, and two others from undefined localities.

Ontario—Nipissing district—lot 6, con. I, of Capreol township, a manganiferous bog iron ore.

British Columbia—

Five samples from the Black Prince claim on Shaw creek.

Seven samples from undefined localities on Vancouver island.

Yukon—Mayo district, 1 sample—exact locality of occurrence not stated.

MOLYBDENUM ORES: One sample from Penn-Canadian Mines, Cobalt.

NICKEL ORES: Four samples from:—

Quebec—Pontiac county, lot 12, range XVI of Eardley.

Ontario—Two samples from Nelson and Langmuir townships; exact location not stated.

British Columbia—One sample from the west shore of the middle channel of Barclay sound, and one from a point near Ikeda bay.

POTASH-BEARING MATERIALS:—

The unusual demand for potash, caused by the requirements of the war, has led to the examination of materials, hitherto disregarded, for their possible content of this valuable salt. One such consisted of coal ash, or "flue dust," from boilers used in heating the west block of the departmental buildings at Ottawa.

It was found to contain 0·96 per cent of potash, of which 0·07 per cent was in a water soluble form.

A sample of potassium chloride, as manufactured from feldspar by the National Potash Co. of Toronto, was analysed and found to contain 64·66 per cent of KCl, 32·13 per cent of NaCl, and small quantities of other impurities.

In addition to the foregoing, 5 samples of supposed potash-bearing salts have been examined:—

Three samples from sec. 2, township 13, range 26, west of 3rd meridian, Sask.

One from Inglebright lake, occurring on secs. 13, 14, 23, and 24, township 16, range 25, west of 3rd meridian, Sask.

One from an alkali lake situated near the railway, 10 miles east of Maple Creek, Sask.

In none of the above was potash detected in more than mere traces.

PYRITOUS (SULPHUR) ORES:—

Thirteen samples of iron pyrites (and pyrrhotite) have been analysed with a view to ascertaining their adaptability, primarily, as sources of sulphur. Those examined were derived from the following localities in Ontario:—

Algoma—

Four samples from the Goudreau pyrite claim.

Vicinity of Franz station.

From the Goetz range, at mile post 2½, on Algoma Central railway.

Kenora—Fourteen miles S.W. of English River station, C.P.R.

Sudbury—Four samples from the townships of Dale and McOwen.

Thunder Bay—

Near Jack Pine station, C.N.R., east of Lake Nipigon.

Schreiber, vicinity of, two samples.

Frontenac county—(Pyrrhotite), lot 10, con. IV, of Olden township.

TUNGSTEN ORES: Four samples; all from Manitoba:—

Falcon Lake district, one sample.

Star Lake district, three samples.

None contained economic quantities of tungsten.

WATERS AND BRINES: One sample from Messrs. Paterson and Ryan's oil well at Glencoe, Ont. Potash was specially sought, but none was detected.

DIVISION OF MINERAL RESOURCES AND STATISTICS.

JOHN MCLEISH, *Chief of Division.*

The Annual Report on mineral production presents not only a complete annual inventory of the mining and metallurgical industries of Canada but includes for each mineral product a discussion of trade conditions, imports, exports, domestic consumption, prices, and, from time to time, discussions of methods of preparation of ores and mineral products, their uses and markets.

The report is based upon statistical data collected by correspondence from some 3,500 smelter, mine, and quarry operators throughout the Dominion, supplemented by records of ore and mineral shipments furnished by railway companies, by records of ore receipts furnished by smelting companies both in Canada and in the United States, and by other data having a direct bearing on mineral production or on mineral consumption.

This series of annual records dates from 1886 and it has been the practice from the beginning to anticipate the complete report, the publication of which must necessarily for various reasons, be delayed until late in the year, by the issue, two months after the close of the year covered, of a "Preliminary Report on the Mineral Production of Canada." While subject to revision, the statistical records of this preliminary report, particularly in recent years, have been found in most products to approximate very closely indeed to the final revised records.

Since 1907 the publication of the complete Annual Report has been preceded by the advance publication of separate chapters as the compilation was completed on the more important mineral products, these advance chapters being re-printed, and included in the Annual Report.

Thus, not only have the final and complete statistical records been available more promptly but the publication of separate parts has made the data more readily available to those interested in particular subjects.

During the past three years the annual collection has been supplemented by monthly, or quarterly records of a number of the more important mineral products, particularly those the production of which became of first importance in the successful prosecution of the war. These included monthly records of the production of pig-iron and steel, of chromite, coal, pyrites, sulphuric acid, etc. The data thus obtained was furnished to the Fuel Controller, the Mineral Resources Commission, the War Trade Board, and other interested departments. In addition to the statistical records, numerous special memoranda and reports were prepared for the information of war boards and commissions as well as for the Imperial and United States Governments on the possible and probable production in Canada of many "war minerals."

In the completion of the final reports on mineral production during the calendar year 1917, Mr. A. Buisson has again compiled the statistics with respect to metals and metallic ores and has prepared the text of the chapters on gold, copper, lead, nickel, silver, zinc, and other miscellaneous metals. He has also compiled the list of "Metal Mines" and the list of "Metallurgical Works in Canada."

Mr. Casey has compiled all the statistics of the production of non-metalliferous products and structural materials as well as the records of imports of mineral products and has prepared for publication the various "Lists of Mine and Quarry Operators," with the exception of the "Metal Mines and Metallurgical Works."

The following reports and lists were completed during the year and sent to press on the dates indicated:—

Reports—

Preliminary Report on the Mineral Production of Canada, during the calendar year 1917. February 26, 1918.

The Production of Copper, Gold, Lead, Nickel, Silver, Zinc, and other Metals in Canada, during the calendar year 1917. October 25, 1918.

General Summary of the Mineral Production of Canada, during the calendar year 1917. November 20, 1918.

The Production of Iron and Steel in Canada, during the calendar year 1917. November 29, 1918.

The Production of Cement, Lime, Clay Products and other Structural Materials, during the calendar year 1917. December 11, 1918.

The Production of Coal and Coke in Canada, during the calendar year 1917. December 16, 1918.

Annual Report on the Mineral Production of Canada, during the calendar year 1917. January 25, 1919.

List of Mine Operators—

List of Metal Mines in Canada. August 12, 1918.

List of Mines in Canada (other than Metal Mines, Coal Mines, etc.). August 12, 1918.

List of Petroleum and Natural Gas Wells (including a list of Petroleum Refineries). August 13, 1918.

List of Coal Mine Operators in Canada. October 7, 1918.

List of Metallurgical Works in Canada. October 28, 1918.

CO-OPERATION WITH THE DOMINION BUREAU OF STATISTICS IN THE COLLECTION OF MINERAL PRODUCTION STATISTICS FOR 1917 AND 1918.

Pursuant to an arrangement entered into with the Dominion Bureau of Statistics, the complete files of statistical production records for the year 1917 collected by this Division were made available to the Dominion Bureau of Statistics of the Department of Trade and Commerce, and the compilation of the mineral production record made in this office was accepted by the Dominion Bureau of Statistics to be included in that Bureau's report on the census of the mining industry. The same co-operation is being continued in respect to the mineral production records for the calendar year 1918.

MINERAL PRODUCTION DURING 1918.

The mineral production of Canada during the calendar year 1918 has already been the subject of a Preliminary Report published on the 5th of March, 1919. As the revised figures are now available, they are presented in the following table.

In an analysis of the mineral production during 1918 it was stated in the Preliminary Report, and the comment applies equally with the revised record, that:—

> "During the past three years greatly increased prices of metals and mineral products have contributed in large measure toward increasing the total value of the mineral production; nevertheless, it is satisfactory to note that out of about 45 items, or products, included in the mineral record, treating clay products and stone quarries each as a single item, no less than eighteen products have reached their highest production in actual quantity during 1918 or 1917."
>
> "The production of cement, clay products, stone quarries and other materials of construction was, as compared with maximum production before the war, reduced almost one-half because of the enforced cessation of building activity, whereas the production of metals and of various non-metals and fuels, most of which entered either directly or indirectly into war's requirements, was greatly increased."

"Comparing broadly the production during the past two years it will be noted that more than half the total increase has been due to the higher prices obtained for coal, and a considerable proportion of the balance of the increase to higher prices of silver, cobalt, and asbestos, though each of these products, with the exception of silver, was also produced in greater quantity than in the previous year."

MINERAL PRODUCTION OF CANADA DURING THE CALENDAR YEAR 1918.'

(Revised Statistics.)

Product.		Quantity.	Value.	Per cent of total.
Metallic.			$	
Cobalt metallic and contained in oxide, etc	*Tons.	1,347,544	3,368,860	1·59
Copper, value at 24·628 cents per lb	"	118,769,434	29,250,536	13·84
Gold	Ozs.	699,681	14,463,689	6·85
Iron, pig, from Can. ore	Tons.	47,444	1,204,703	0·57
Iron ore sold for export	"	118,472	498,999	0·24
Lead, value at 9·250 cents per lb	Lbs.	51,398,002	4,754,315	2·25
Molybdenite, Mo S_2 contents, valued at $1.15 per lb.	"	378,029	434,733	0·21
Nickel, value at 40 cents per lb	"	92,507,293	37,002,917	17·51
Platinum	Ozs.	39	2,560	
Silver, value at 96·772 cents per lb	"	21,383,979	20,693,704	9·79
Tungsten concentrates	Lbs.	27,088	11,700	
Zinc, value at 8·159 cents per lb	"	35,083,175	2,862,436	1·35
Total			114,549,152	54·21
Non-Metallic.				
Actinolite	Tons.	228	2,508	
Arsenic, white and in ore	"	3,560	563,639	0·27
Asbestos	"	141,462	8,936,804	4·23
Asbestic	"	16,797	33,993	
Chromite	"	21,994	867,122	0·41
Coal	"	14,977,926	55,192,896	26·12
Corundum	"	137	26,112	
Feldspar	"	18,782	112,728	
Fluorspar	"	7,362	156,029	
Graphite	"	3,114	248,870	0·12
Graphite, artificial	"	904		
Grindstones	"	3,072	83,005	
Gypsum	"	152,287	823,006	0·39
Magnesite	"	39,365	1,016,765	0·48
Magnesium sulphate	"	1,949	14,565	
Manganese	"	440	6,230	
Mica	"	747	271,550	0·13
Mineral pigments:—				
Barytes	"	640	10,165	
Oxides	"	17,317	112,440	
Mineral water	"		154,468	
Natural gas	M. cu. ft.	20,140,309	4,350,940	2·06
Petroleum	Bls.	304,741	885,143	0·42
Phosphate	Tons.	140	1,200	
Pyrites	"	411,616	1,705,219	0·81
Quartz	"	268,155	629,813	0·30
Salt	"	131,727	1,285,039	0·61
Talc	"	18,169	119,197	
Tripolite	"	500	12,500	
Total			77,621,946	36·74

* Short tons throughout.

MINERAL PRODUCTION OF CANADA DURING THE CALENDAR YEAR 1918[1]—*Concluded.*

(*Revised Statistics.*)

Product.		Quantity.	Value.	Per cent of total.
Structural Materials and Clay Products.			$	
Cement, portland	Brls.	3,591,481	7,076,563	3·35
Clay products:—				
Brick, common	No.	164,970,087	1,879,811	0·89
Brick, pressed	"	40,146,536	639,083	0·30
Brick, paving	"	......	......	
Brick, moulded and ornamental	"	357,793	28,296	
Terra Cotta	"	174,752	15,146	
Fireclay and fireclay products		......	404,824	0·19
Fireproofing	No.	28,087	226,798	0·13
Hollow Bldg. Blocks	"	1,402,158	40,876	
Kaolin	Tons.	863	19,299	
Pottery		......	130,242	
Sewerpipe		36,574	699,774	0·33
Tile, drain	No.	19,762,101	499,340	0·24
Lime	Bus.	6,363,951	1,876,025	0·89
Sand-lime brick	No.	14,589,324	186,066	
Sand and gravel	Tons.	11,262,282	2,367,018	1·12
Slate	Sq.	933	5,124	
Stone:—				
Granite		......	590,871	0·28
Limestone		......	2,342,403	1·11
Marble		......	550	
Sandstone		......	102,750	
Total		......	19,130,799	9·05
Grand total		......	211,301,897	100·00

[1]In presenting a total valuation of the mineral production as is here given, it should be explained that the production of the metals, copper, gold, lead, nickel, silver, and zinc is given as far as possible on the basis of the quantities of metals recovered in smelters, and the total quantities in each case are valued at the average market price of the refined metal in a recognized market. There is thus included in some cases the values that have accrued in the smelting or refining of metals outside Canada.

DRAUGHTING DIVISION.

H. E. BAINE, *Chief Draughtsman.*

During the year 1918, in addition to the general work of this Division, instructions were received to supervise the compiling and printing of maps, diagrams, charts, etc., in connexion with the Canadian Munition Resources Commission, of which Mr. George C. Mackenzie of this Branch is secretary.

Up to date, five maps have been printed, and seven are in the hands of the printer.

We have also been able to introduce a system of filing for halftone blocks, zinc cuts, and photos belonging to the various reports, and which have been accumulating since the organization of the Branch.

The following is a list of maps published during the calendar year 1918:—

477. Peat Bogs investigated in Ontario.
484. Peat Bogs investigated in Quebec.
485. Girard Peat Bog, St. Johns and Napierville counties, Que.
486. Pont Rouge Peat Bog, parish of Cap Santé, Portneuf county, Que.
487. Peat Bogs investigated in New Brunswick.
488. St. Stephen Peat Bog, Charlotte county, N.B.
489. Hayman Peat Bog, parish of St. Stephen, Charlotte county, N.B.
490. Seely Cove Peat Litter Bog, parish of Pennfield, Charlotte county, N.B.
491. Pocologan Peat Bog, Charlotte county, N.B.
492. Musquash Peat Bog, St. John county, N.B.
586. Mechanical drawings, diagrams, charts, etc.
650. Blue prints.

Maps prepared for the Canadian Munition Resources Commission:—

Yukon	scale:	16 miles	= 1 inch.
Nova Scotia	"	8 "	= 1 "
New Brunswick	"	7·89 "	= 1 "
Montreal sheet	"	7·89 "	= 1 "
Montmagny sheet	"	7·89 "	= 1 "

Maps in hands of printer:—

British Columbia	scale:	17½ miles	= 1 inch.
Alberta	"	17½ "	= 1 "
Saskatchewan	"	17½ "	= 1 "
Manitoba	"	17½ "	= 1 "
Ontario	"	17½ "	= 1 "
Quebec	"	17½ "	= 1 "
Prince Edward Island	"	7·89 "	= 1 "

REPORT COVERING THE OPERATIONS OF THE DOMINION OF CANADA ASSAY OFFICE, VANCOUVER, B.C., DURING THE YEAR ENDING DECEMBER 31, 1918.

REPORT OF THE MANAGER, G. MIDDLETON.

I.

The following is a report covering the operations of the Dominion of Canada Assay Office, Vancouver, B.C., for the calendar year ending December 31, 1918.

Instructions were received on January 24, 1918, to ship the gold bullion purchased by this office to the Royal Mint at Ottawa; the returns, however, do not compare favourably with those of former years, there being a difference of $659.43 against this office on bullion shipped to the Royal Mint, as shown in this report under the heading "Disbursements, Receipts, etc."

GOLD BULLION.

There were 1,358 deposits of gold bullion received, melted, assayed and purchased; before disposing of same the small deposits were assembled and melted into large bars, which were also assayed. A total of 1,420 meltings and 1,420 assays were required in connexion with the purchase and disposal of the bullion, all assays being run in quadruplicate.

Two hundred and twenty ounces of quartation silver were manufactured and punched into discs ranging in weight from 25 to 750 mgrms.; 13,600 cupels of different sizes were also manufactured and 395 pounds of slag treated and the values contained in same recovered.

The aggregate weight of the gold bullion deposits before melting was 241,762·77 troy ounces and after melting 238,245·13 troy ounces, showing a loss in melting of 1·455 per cent. The loss in weight by assaying was 27·11 troy ounces, making the weight of bullion after melting and assaying 238,218·02 troy ounces, the average fineness of same being ·827¾ gold and ·138 silver.

The net value of the gold and silver contained in deposits was $4,099,595·80, and was received from the following sources:—

Source.	Number of deposits.	Weight.		Net value.
		Before melting and assaying.	After melting and assaying	
		(Troy ozs.)	(Troy ozs.)	$
British Columbia	872	120,280·75	118,046·88	2,175,511 48
Yukon Territory	485	121,463·50	120,153·96	1,923,764 66
Alberta	1	18·52	17·18	319 66
	1,358	241,762·77	238,218·02	4,099,595 80

CREDITS AND DISBURSEMENTS FOR THE PURCHASE OF GOLD BULLION.

Unexpended balance, "Letters of Credit," January 1, 1918	$ 155,678 09	
Credits established	4,400,000 00	
Balance written off at close of fiscal year, March 31, 1918	....	$ 109,374 04
Disbursements	....	4,099,595 80
Unexpended balance, "Letters of Credit," December 31, 1918	....	346,708 25
	$4,555,678 09	$4,555,678 09

DISBURSEMENTS AND RECEIPTS FOR THE PURCHASE AND SALE OF GOLD BULLION.

Value of bullion on hand, January 1, 1918	$ 53,903 70	
Disbursements for the purchase of bullion	4,099,595 80	
Receipts from bullion sold for manufacturing purposes	....	$ 126,975 07
Receipts from bullion shipped to United States Assay Office, Seattle, Wash., U.S.A.	....	89,011 54
Receipts from bullion shipped to Royal Mint, Ottawa, Ont.	....	3,732,525 56
Value of bullion shipped to Royal Mint, Ottawa, for which returns have not yet been received	....	111,643 54
Value of bullion on hand, December 31, 1918	....	94,845 45

Difference in favour of this office on bullion sold for manufacturing purposes..	2,020 65	
Difference in favour of this office on bullion shipped to United States Assay Office, Seattle, Wash., U.S.A..	140 44	
Difference against this office on bullion shipped to Royal Mint, Ottawa..	....	659 43
	$4,155,660 59	$4,155,660 59

CONTINGENT ACCOUNT.

Unexpended balance, January 1, 1918..	$ 330 85	
Funds provided per official cheques Nos. 2211, 2429, 2663, 9, 188, 476, 751, 1013, 1275, 1501, 1704 and 2086..	2,775 00	
Amount remitted Receiver General per draft No. 179 at close of fiscal year, March 31, 1918..	....	$ 47 59
Expenditure..	....	2,992 66
Unexpended balance, December 31, 1918.. ..	....	65 60
	$3,105 85	$3,105 85

CONTINGENT EXPENDITURE.

Fuel (gas)..	$ 762 15
Power..	274 22
Express charges on bullion (Vancouver, B.C., to Seattle, Wash., U.S.A.)..	74 62
Express charges on bullion boxes (Ottawa, Ont., to Vancouver, B.C.)..	51 30
Electric vault protection..	300 00
Postage..	70 00
Telephones..	86 95
Expressage, freight, etc., on supplies and new equipment.. ..	163 54
Installing new equipment..	111 07
Assayers' and melters' supplies (purchased locally)..	859 72
Sundries..	239 09
	$2,992 66

NEW EQUIPMENT.

During the month of November a No. 15 Case gas muffle furnace was received and installed in melting room.

PROCEEDS FROM SALE OF RESIDUES.

Residue recovered from slags, sweepings, etc..	$881 37
42 empty acid bottles..	5 04
	$886 41

NOTE.—12·02 ounces silver (recovered from slags, etc.) were turned over to assayers on March 21, 1918, for assaying purposes.

RESIDUES ON HAND, DECEMBER 31, 1918.

Residue recovered from slags, sweepings, etc..	$700 95
22 empty acid bottles.	

MISCELLANEOUS RECEIPTS.

Draft No. 479, in favour of Deputy Minister of Mines (a payment for treating 22 ounces gold leaf sign scrapings)..		$ 1 50
Draft No. 482, in favour of Deputy Minister of Mines (a payment for treating 32·98 ounces old silver)..		5 50
Draft No. 503, in favour of Deputy Minister of Mines (a payment for 1 old analytical bullion balance)..		35 00
Draft No. 511, in favour of Deputy Minister of Mines (a payment for melting 0·33 ounces bullion)..	$1 00	
(A payment for 1 special assay)..	2 00	
		3 00
Draft No. 514, in favour of Deputy Minister of Mines (a payment for special assay)..		3 00
Dráft No. 555, in favour of Deputy Minister of Mines (a payment for 16½ pounds mercury (impure)..		16 50
Draft No. 508, in favour of Deputy Minister of Mines (a payment for treating 11 pounds slag)..		2 00
Draft No. 587, in favour of Deputy Minister of Mines (a payment for platinum and gold recovered from samples of sands assayed as a whole)..		35 37
		$101 87

COMPARATIVE STATEMENT OF GOLD BULLION DEPOSITED DURING THE PAST SIX YEARS.

Calendar year.	Number of deposits.	Weight.	Net value.
		(troy ozs.)	$
1913	783	111,479·95	1,448,625 37
1914	1,112	166,148·83	2,029,251 31
1915	1,901	183,924·49	2,736,302 31
1916	1,779	180,292·83	2,828,239 65
1917	1,583	191,626·04	3,257,220 71
1918	1,357	241,762·77	4,099,595 80

II.

PLATINUM.

Instructions were received on July 15 to make preparations for the assaying at this office of platinum-bearing ores and sands in connexion with the operation of the Canadian Munitions Resources Commission, and an assayer was sent from Ottawa for that work. Further instructions were received on July 19 to also make preparations to purchase platinum metals for the Imperial Munitions Board and the refining and melting of platinum deposits were in due course undertaken by a member of our assaying staff.

Additional floor space and equipment had to be obtained in order to carry on these two branches of work. Three adjoining rooms were secured, but they had to be remodelled and enlarged, which was arranged by extending them across the lane owned by the Government. An entrance to the platinum division was made from the melting room and the former outside entrances to the rooms acquired built up. The new equipment consists of two fume cupboards, electric still, crusher, pulverizer, motor, No. 15 Case gas muffle furnace, melting equipment, analytical and button balances, operating table, etc.

One hundred and eighty-nine samples of platinum-bearing ores and sands were assayed, of which one hundred and one were for the commission and the balance for prospectors and others. On November 20 the assayer who was sent from Ottawa left the service and one hundred and twenty-one unassayed samples then on hand were

taken by the commission to Ottawa, but instructions have since been received that assays of platinum-bearing ores and sands may continue to be made.

Seventy-nine deposits of crude and scrap platinum were received, but on account of the market being established so late in the season, there was only a portion of the output of crude platinum deposited at this office.

Instructions were received on December 14 to discontinue the purchase of platinum after December 31, 1918. Settlement will in due course be made for the deposits received towards the end of December and the whole of the platinum metals purchased will thereafter be shipped to the Imperial Munitions Board, care of the Royal Mint, Ottawa.

PLATINUM AND PLATINUM ORES ACCOUNT.

Funds provided—		
July 23, 1918—Transferred from Ottawa.. ..	$2,000 00	
Aug. 5, 1918— " "	1,100 00	
Sept. 24, 1918— " "	500 00	
Nov. 12, 1918—Per official cheque, No. 1673..	225 00	
Dec. 20, 1918— " " No. 2086..	75 00	
	$3,900 00	
Expenditure..	......	$3,882 20
Unexpended balance, December 31, 1918..	......	17 80
	$3,900 00	$3,900 00

EXPENDITURE FOR EQUIPMENT AND SUPPLIES IN CONNEXION WITH THE ASSAY OF PLATINUM-BEARING ORES AND SANDS AND PURCHASE OF PLATINUM METALS.

Equipment and supplies..	$3,599 80
Expressage and freight on equipment..	108 63
Fuel (gas)..	81 24
Power..	22 00
Sundries..	70 53
	$3,882 20

CREDITS AND DISBURSEMENTS FOR THE PURCHASE OF PLATINUM TO DECEMBER 31.

Credits established..	$9,000 00	
Disbursements..	......	$7,955 87
Unexpended balance, December 31, 1918.	......	1,044 13
	$9,000 00	$9,000 00

LIST OF REPORTS, BULLETINS, ETC., PUBLISHED DURING THE YEAR 1918.

MARC SAUVALLE, *Chief of Publishing and Translating Division.*

S. GROVES, *Editor Department of Mines.*

337. Catalogue of Mines Branch Publications (Ninth Edition). Published September 4, 1918.
452. Building and Ornamental Stones of Canada, Vol. V: Province of British Columbia. Report on—by W. A. Parks, Ph.D. Published August 29, 1918.
454. Mines Branch Summary Report for 1916. Published January 25, 1918.
468. Clay Resources of Southern Saskatchewan. Report on—by N. B. Davis, M.A., B.Sc. Published August 3, 1918.
471. Production of Copper, Gold, Lead, Silver, Zinc, etc., for the calendar year 1916. Bulletin on—by John McLeish, B.A. Published March 21, 1918.
472. Mineral Springs of Canada: Part II—The Chemical Character of Some Canadian Mineral Springs. Report on—by R. T. Elworthy, B.Sc. Published August 21, 1918.
474. Mineral production of Canada for calendar year 1916. Annual Report on—by John McLeish, B.A. Published August 6, 1918.
476. The Occurrence and Testing of Foundry Moulding Sands. Bulletin on—by L. H. Cole, B.Sc. Published April 2, 1918.
478. Preliminary Report on the Mineral Production of Canada during the calendar year 1917. By John McLeish, B.A. Published March 6, 1918.
479. Analyses of Canadian Fuels: Part I—The Maritime Provinces. Bulletin on—compiled by Edgar Stansfield, M.Sc., and J. H. H. Nicolls, M.Sc. Published July 31, 1918.
480. Analyses of Canadian Fuels: Part II—Quebec and Ontario. Bulletin on—compiled by Edgar Stansfield, M.Sc., and J. H. H. Nicolls, M.Sc. Published July 31, 1918.
481. Analyses of Canadian Fuels: Part III—Manitoba and Saskatchewan. Bulletin on— compiled by Edgar Stansfield, M.Sc., and J. H. H. Nicolls, M.Sc. Published July 17, 1918.
482. Analyses of Canadian Fuels: Part IV—Alberta and Northwest Territories. Bulletin on—compiled by Edgar Stansfield, M.Sc., and J. H. H. Nicolls, M.Sc. Published July 29, 1918.
483. Analyses of Canadian Fuels: Part V—British Columbia and Yukon Territory. Bulletin on—compiled by Edgar Stansfield, M.Sc., and J. H. H. Nicolls, M.Sc. Published July 17, 1918.
493. Mines Branch Summary Report for 1917. Published December 3, 1918.

List of Mine Operators—

- List of Coal Mine Operators in Canada.
- List of Mines in Canada (other than Metal Mines, Coal Mines, Stone Quarries, Clay Plants, etc.).
- List of Metal Mines in Canada.
- List of Metallurgical Works in Canada.
- List of Petroleum and Natural Gas Wells.

FRENCH TRANSLATIONS.

402. French translation: Feldspar in Canada. Report on—by H. S. deSchmid, M.E. Published March 19, 1918.
412. French translation: Cobalt alloys with non-corrosive properties. Report on—by H. T. Kalmus, B.Sc., Ph.D. Published January 30, 1918.
455. French translation: Mines Branch Summary Report for 1916. Published August 7, 1918.
475. French translation: The Mineral Production of Canada during the calendar year 1916. Annual report on—by John McLeish, B.A. Published October 1, 1918.

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